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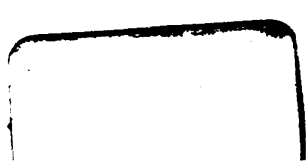

RETRIEVAL AT PANAMA

THE PANAMA CANAL.
PROJECT OF LINDON W. BATES.

RETRIEVAL
AT
PANAMA

By

LINDON W. BATES

MEMBER OF

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DEDICATION.

To my wife, co-laborer in the production of these papers, the book is inscribed.

INTRODUCTION.

NEW YORK, March 16th, 1907.

TO THE PUBLIC:—

In his elucidation of the Panama Canal problem, through *The New York Press,* the service which Mr. Lindon W. Bates has performed is of such value to our Nation and to all civilization, that there ought to be no unnecessary restriction on the dissemination of his masterly articles, among both the members of his profession and the public at large. For what he is doing to make possible the construction of the RIGHT waterway across the Isthmus, *The New York Press* as one of the champions of sound American institutions, is profoundly grateful. Not only is it a great pleasure to grant Mr. Bates all rights to use in any manner he sees fit the material which he has contributed to our columns from his wealth of scientific attainments and technical experience with the greatest engineering projects of the globe, but it is a duty.

In extending to him the freest employment of all his articles published in our columns, we can only repeat, in behalf of our hundreds of thousands of constituents, our heartfelt thanks to him for his patriotic labors.

ERVIN WARDMAN,
Editor.

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PREFACE.

Nearly four years ago the United States intrusted the Panama Canal to an Isthmian Commission, which was placed under the personal direction of the Secretary of War.

After a notable engineering conflict, of half a century, Congress pronounced for a lock canal. The vote endorsed the general type only. There was no legislative acceptance of the hazardous and unsound features disclosed to the Senate Investigating Committee. The official estimate for the completion of the waterway was nearly one hundred and forty millions. The original grant was one hundred and forty-five millions inclusive of Sanitation and Zone Government. With the eight millions, allowed by executive order in September, 1907, and the various sums authorized by Congress for canal purposes the appropriations now total $85,310,201.08. This is exclusive of the $2,298,367.50 voted for retiring the railway bonds and reported still part of the "balance available July 1, 1907."

The call for the next fiscal year beginning July, 1908, is for another 33 million. At the next session of this Congress then only 25 to 27 millions will remain to call, to cover the entire expenses for the remaining years of the construction era. Were this time but seven years and the rate never above the last two demands, the deficit without interest would still amount to above two hundred million dollars.

Over 41,000 men are upon the books. The Isthmus pay roll including the railroad force is about one and three-quarter millions a month. In eight years such a rate will amount to 168 millions, for wage alone.

The public has not learned from any official announcement, the monumental deficits in sight. When this Congress grants the new 33 millions already asked there will be left not *a seventh* of the 195 millions allotted by the Spooner Act to the purchase and the construction of the Panama Canal. There must be, with the present design, over ten more draining years and a total cost with interest of upwards of 550 millions. Other public works must be scaled or deferred in an era of financial stress to pay for this insatiate scheme, whose stupendous structures with no justification in reason or expediency involve the maximum hazard to our defense and the minimum service to the world's commerce.

The facts of the Panama situation and technique and the inevitable consequences of the effort to carry out the adopted scheme have no general realization.

Subsequent to the publication early in 1907 of the papers, which are incorporated into this book, a new Isthmian Canal Commission was appointed.

The simultaneous abandonment of the iniquitous Percentage and Chinese Labor Contracts, opened apparently a better prospect for the waterway.

With the advent of the new men came certain palliative measures. The conviction became general that engagements, henceforth, would be normal, regular and responsible; that excessive and useless purchases would be discountenanced and that whatsoever these Engineers were directed to execute, would reflect the best traditions of the Service.

The months have justified the faith so far as it could be lived. In devotion, silence and dignity, they have bent to the task. But they were set against cumulative odds. Details they might change, but the 85 foot plane, its elements and construction system were a sealed closed case; the old entanglements and evils were made a sacred legacy. The Lock-Flights and the Great Dams became the Sisyphus load, which they in passing turn, must roll up the precipitous steep of ever-rising deficits. They might modify, not rescue or redeem. They can but in manful self-sacrifice carry the work along till the awakened country shall call to the great accounting.

This fourth Commission has just submitted its first Report, that of 1907. It is much the best annual review yet made. It is an open and conscientious record. No line is contributed in commendation of the Government Project. The thing "adopted" and imposed is taken with the resignation of discipline. In its creation they had no part. Responsibility for the technique and the foundations is judiciously riveted where it belongs. It is left with the "experts" whose Panama prototype, the Wachusett Dam, in its crucial mass under less than two-thirds the destined duty was sliding away while they were reëndorsing their own assurances at the Isthmus.

Execution by contract, though first favored, is in their last analysis opposed. The decision recognizes that no contractor could with this design and method make any notable difference in results. Their verdict in the premises is just. No successful contract is possible. The report adds further the "labor problem is still an unsolved one." There can be no solution with such a plan.

Certain beliefs regarding the Canal have come into extended acceptance and the cymbals of the early French days are tinkling again in our own. The illusion is cherished that for the nearly seventy-two and a half millions of dollars expended or pledged Dec. 31, 1907,—that is, for one-half of the all-inclusive hundred and forty-five millions appropriated—the equivalent of *one-sixth* of the Canal prism excavation has been made. But this is not so. The ex-Chairman a year ago announced the deepening of the Culebra by 65 feet and the Message of Dec. 1906, gave it support. The "Canal Records" of September, 1907, show that the Culebra Division has not yet been lowered one foot. Its rocky depths are still unpierced.

Considering the mountain-like dams almost untouched, the millions of cubic yards of under-water rock unessayed and unprepared for; the swamp-founded, lake-exposed railway hills unbuilt; the lock pits undug in indurated clay and miasmic morass, and remembering the vast yardage which in and outside the prism at Colon and LaBoca, swelling the welcomed totals, is being brought back by the sea, whose currents wash their tally from the count, *not five per cent.* in value of the excavation and embankment is permanently done.

The Divide Cut, opened at such cost in money and life by the French, has been widened, and the foot of the ever-advancing slide has been continuously pared. Spoil has been nearly all hauled to nearby dumps, but these deposit areas are now full.

The Report of 1907 says:

"The great problem in the construction of that portion of the canal included in the Culebra Division is the disposal of the excavated material. In the main this has been disposed of at various localities favorably situated with regard to the cut. The systematic performance of the work and the necessity for additional material in completing other parts of the work have made it necessary to arrange for such a disposition in the future as will be most beneficial to the work in its entirety." Ahead now are the long hauls to the huge Gatun and Pacific Dams and Railway fills; ahead are the endless sortings for their sound rock; ahead are the liftings to growing heights of the sixty millions of dead weight tons; ahead are the deepenings, the pumpings, as the Culebra floor gets below the Chagres, and the seasons' rains gather into its defile; ahead are the saturated, viscous high deposits across the Gatun and Rio Grande swamps; ahead are dragging years and flying millions.

The public believes the past season to have been fecund in

great achievements. The output figures read well. But in these record months two-fifths of the excavation has been from the soft silt and sand of the canal approaches. The old French "dragues" and the hopper dredge, have dug for a dime a yard. Tens of millions of dollars in buildings and quarters, sanitation and hospitals, tracks, plant, labor, materials and supplies, administration and Government belong with the other three-fifths accomplished. The monthly outgo shows twenty-five times as much expense incident to dry work as to wet. Is there no logic in favor of a plan which increases the wet percentage?

An impression is abroad that the Gatun Dam is found to "rest almost everywhere upon the rock." The Gatun Dam is to rest almost *nowhere* upon rock. The foundations are alluvial and artesian. Later borings and test-pits are supposed to testify to satisfactory rock foundations for the Flights of Locks. The Report reads: "To actually develop the *character* of the foundations on which the locks are to rest five test-pits, each 6 feet by 8 feet, were sunk to the depths of the lock walls at Gatun, two at Pedro Miguel and one at the Spillway in Gatun Dam. On completion of the test-pits a Board of Consulting Engineers" (the Bohio expert, the Wachusett Dike expert and his colleague) "made a personal examination of the material. Under date of May 2, 1907, it reported as follows: 'We beg to record that we found that all the locks of the dimensions now proposed will rest upon rock of such a character that should furnish a safe and stable foundation.'"

The five test pits at Gatun showed *character* but not *extent* and they could not change the permeable sands, gravel and clay underneath the thin rock blanket pierced as the official profiles show, at points vital to the locks. Of the test-pits four were in the upper half of the upper lock, none was in the lower lock which is all in the morass.

"Since then careful borings have been continued over the entire area in order to secure a contoured plat of the rock-surface with a view to the economical adjustment of the locks to the site" the Report continues.

Here again are the data, the conclusive evidence of certain facts. By putting the lower approaches and the lower lock all in the Swamp of Quicksands; by making part of the gates of the rolling type to save room, against every previous advice of French and American Boards; by setting in the most dangerous position a futile safety device to conserve the Lake level in event of gate accident, because there is no other place; by

founding the upper approach piers upon piles in soft ground, the flight has been squeezed onto the pierced rock blanket underlaid by pervious strata, porous and saturated when the lake is filled.

It is supposed also that the Isthmus is sanitized and that a miracle of victory has been won. An analysis of the elaborate statistics from first and last shows the claim to be cruelly and lamentably untrue. The latest available Sanitary Report, that of September, 1907, opens with these words:

"The health conditions of the Zone continue good, as is usual at this time of the year the sick rate is decreasing." What are a few of the conditions attested in the mass of records? The population has been since May, 1906, continuously inflated and the sick and death rates are low only by virtue of this discrepancy. Cheering comparisons are made with French mortality and hospital rates. For the American exhibit a divisor of the "full number on the rolls" is used. The full number is some 40% higher than the "working effectives." For the French exhibit their effectives only are counted. In this very month of September, 1907, nearly 15% or one man in seven of the 4,200 Americans went to the hospital. Over 10% went to sick camps. Of the 7,462 foreign whites—Spaniards, Italians and Greeks—20 3/10% went to the hospitals; over 10% to sick camps and their death rate was six and a half times that of the Americans. Over two-thirds of the hospital entries were of whites, and they received 16,010 dispensary treatments. The hospital rate of the white is six times that of the colored man and his dispensary rate is stated as four times as high. The blacks die five times as fast as the whites, yet marvelously they take sick one-sixth as often! This outlines the sanitary story. Small wonder the labor problem is unsolved.

A latest departure is just announced from Washington "the President has approved the recommendation that a radical change be made in Canal plans. This change consists in the relocation of the dams and locks which it was purposed to place at La Boca. They will now be placed at Miraflores instead."

The valuable Terminal Lake is to be therefore abandoned, the morasses preserved and the tremendous cost of digging through the buried rock ridges of the lower Rio Grande valley in this four mile sea level stretch added to the Canal estimate. To what gain? Military safety it is hinted. With 12 and 14 inch guns shooting comfortably ten miles and more and dirigible

balloons able to traverse at will the narrow Isthmus? Surely this is not the explanation.

The plan now adopted was considered by the International Board and Commission unfavorably. It was reconsidered and reported on by the late Chief Engineer. The minutes of the 114th meeting of the Isthmian Commission, September 6, 1906, read:

"The question, as you are aware, was some time ago raised as to whether it would not be expedient to extend the sea level approach to these locks and dams some distance inland from La Boca, and to locate the dams and locks at or in the vicinity of Pedro Miguel, Miraflores or at some adjacent point, but, as I advised you in the report of yesterday, I have been unable to find a location where these locks and dams can be built that will afford stable foundations."

This development leads one to ask anew who is designing the Government Canal? The 85-foot plan has been held up before the American people as strongly entrenched in the judgment of International Expert Minority, Commission, and various Chief Engineers. But not one feature of the entire waterway from approach to approach is as the Experts and Commission presented it. The International impractical five million dollar breakwaters have been dropped, and the International reef-ridden Pacific approach. The Expert alignments at the Atlantic terminal and in the Mindi-Gatun section have been altered. The Ancon-Corozal and Ancon-Sosa dams have been given up, and a Stevens dam substituted. The Expert's "mud silt" has been repudiated for the heart of the dam and their "cutters" for the indurated rock excavation. The Terminal Lake is abandoned and the La Boca dam and lock sites. The International stipulation for cutting off the flow under the Gatun Dam has been quietly shelved, and the monster structure is to be built without this safeguard. The lock lengths 790 to 820 feet with closed gates are ordered at 1,000 feet and the widths are to be increased in proportion. Is this the Panama Canal design for whose preparation engineers were summoned from the four quarters? The iniquitous 85-foot plane is conserved and high dams and lock flights as it compels, but in virtually every detail the Expert's recommendations have been thrown overboard, the Commission's earlier acceptances have been likewise repudiated and though one by one the engineers depart, Panama Canal designs different and contradictory keep coming forth regardless

No minds, however able or willing, can change the nature of this plan. The one only way of redemption lies in a different canal design, in separate locks, low dams, extended use of water and waterborne plant and a program of synchronous execution. This is the way of all technical, sanitary, executive and financial salvation which can still be secured. It is also the true solution of the labor problem, since it substitutes for a large part of the army of foreign colored and white labor, relatively small forces of skilled Americans.

Before the colossal deficits and the masked evils have shadowed the faith of the American people in their ideal let retrieval come at Panama.

FOREWORD.

The need to America and to the world of the Isthmian waterway is so axiomatic and so imperative that its construction has become a very cornerstone of our national policy. The Panama Canal first, last and altogether has been accepted as the shibboleth of both parties and the motto of a united people. So radical is the necessity for its creation that there would be full warrant for the basic premise, "the canal at any cost." America has passed the stage of a small band of colonies struggling for an Albany post road or a western reserve highway to reach her confines. We have become the nation of nations, with our hands clasping the globe.

The country needs the waterway most pressingly to safeguard the territories under its flag. Whatever may be the divergence of opinion as to the wisdom of becoming possessed of an Oriental domain, one thing is certain—no American would tolerate our being dispossessed of it by violence. If ever we shall choose to give autonomy to the Philippines or bid them godspeed, well; but the suggestion of having them wrested from us would be unwelcome indeed. That we may be able always to reach and defend our dependencies in the far oceans, the Panama Canal must be put through.

Again, we have become the world's greatest producers and are dependent not for a small market but for the range of the whole world's markets. The Orient is the nearest large locus of consumption unpreëmpted. We must have our share of its give and take. South America is the next new continent lying fallow for commercial quickening. This too, must be drawn to us for mutual fruitfulness.

The recesses of our own land are being all peopled, and the waste places of all lands everywhere are being seized by the strong and brought to human uses. Competition is reaching an intensity and a universality such as Mother Earth has never before felt. The tension is extreme and the bow is being bent more and more to the breaking.

National Defense.—This ubiquitous stirring and general outreaching is not a chance or a passing phenomenon. It is the movement deep down at the base of things, where growth lies and the tremendous outpressures of growth. It is the

activity of numbers increasing steadily. Our globe has become a teeming hive, where swarmings and overflows make ever new demands. These demands are built out of cruel things—wants. Needs in every guise lie at the base of competition—the fierce primeval life-needs, whose ultimate arbiter at any moment becomes the sword. Would we enjoy the fruits and privileges of our great plenty and our expanding good? Then must we be able to defend them at every point against those who lack. He were a fool who, facing a fight, would throw away his sword or his armor, or weaken himself at any mortal part. So a nation which, in this day of an east and a west, strips itself of its might or leaves itself shorn of its fullest power of attack and defense has betrayed the mission of its race; for destiny is still the cruel Roman with her thumb down for the weak. All our interests—industrial, commercial and national—center to the same issues.

By our race right to leadership, therefore, and by our full resolve to hold our people high above the outer pressures, by all that we can be and shall be, we support the Panama Canal, which is an integral link in our capacity and our power.

There is yet another aspect, little moving perhaps to the sphinx holding the highway to the treasury, but still warm, we believe, under the heart of America. Sentiment may not move the mart nor make change on the Rialto, but we own to a lurking misgiving, if it be not after all the secret energy which keeps grinding the slow, sure mills of the gods. The Panama Canal embodies the vision of the seers and the dreams of the prophets through four centuries.

Failure of the French.—It was in 1502 that Columbus, "Admiral of the Sea of Darkness," broken in body and broken in heart, sailed out on his last voyage of desperate retrieval to pierce the legendary strait and redeem his fruitless promise of Cathay. "Porto Bello"—Porto Bello shalt thou ever be to us whose harbor stirred his brief sad gladness. Here was the fancied entrance; here was the narrow way; here opened the passage that was his pawn and pledge. But the Crocodile Chagres was pitiless and the mountains crushed his hope. He sailed away from his new world finding only the last great strait of death. We believe that our Columbia will be glad to have redeemed the promise of Columbus and to have opened at last, in the very gateway where he came seeking it, his way to far Cipango.

Through the long after years the search went on. Spain, Portugal, England, the Netherlands, all Europe beat the mid coast up and down on the same bootless quest. Then Cortez, resolute to conquer what obdurate nature had denied, planned to force a strait by way of the turbulent Chagres, and many after him of the hardy Hidalgo stock sought to cleave the continent. But already the great empire was becoming prey to disintegrating forces. Frank and fiercer Saxon were becoming supplanters, and her energies were drawn from the new world back to the defense of the old. And the years of the centuries passed, but the hope never died.

Then, at last, France achieved the great feat of linking the Atlantic and the Indian seas. She had realized, by the east, the dream of the Admiral and had opened the first new way to his Mangi and Cathay. Proud and exultant, this nation, foremost of the race in mighty daring, because foremost in loyalty to ideals, rose to compass the second strait. Her name will ever be linked with that of Panama and, in defiance of all, all, linked in honor. For in the long story of her wars and her glory there is nothing more truly heroic than the legions of her sons storming through ten desperate years the trenches of the rock-ribbed Culebra and battling with the torrents of the ruthless Chagres.

It is because the narrow pass we call the Zone represents the efforts, the hopes, the visions of the pioneers and the prophets of empire for four hundred waiting years, that the land of it is sacred sod, and the water of it shall be the keeping of our elected covenant to all the world. By this thread shall the oceans become one, and the dissevered continent be rebound in a unity her mountains could not bring. This water band, securing to America omnipotence in war, shall be the fillet on her brow of peace.

So to the Panama Canal, life, life and everlasting life! Let no man ever challenge this. But by so solemnly and unreservedly as we do pledge the canal, by so solemnly must we all set ourselves to see that the country gets it. After four centuries of birth pangs the child must not be delivered still-born, or a monster, or a cripple. It must be a goodly, normal man-child, fit for its work of service.

Fundamentals.—There are many forms of enterprise whose fortunes are pivoted upon special expert judgment. Mining is one of these, navigation is another, surgery is a third. The first

indispensable in this expert is the power of rightly diagnosing conditions and elements; the next the power of rightly prescribing or adjusting the elements. As he possesses or does not possess these qualifications the expert is a failure or a success. It counts nothing that he is an amiable gentleman or that he is favored at court. He is the wrong mind for the undertaking, and the loyalty of its friends can be measured in nothing so surely as in their fearless and open elimination of such an one from its destinies. The Panama Canal is an enterprise with its very fulcrum in the right expert judgment and its whole execution at the other end of the lever.

It is the greatest public undertaking of this or any other era. In it are enlisted a vast capital, a nation's pride and honor before the world, and an integral factor of that nation's safety and dominion in case of war. In its every feature and every phase, therefore, it is of supreme concern and should be entrenched within the safest and highest technical citadel.

Business men will appreciate the great handicap under which a venture is brought to the public again after its bankruptcy. When this bankruptcy has been attended with colossal mistakes, deceptions and failures, the public scans the proposition warily and exacts a vouching and a showing which a previous clean record would have averted. The Panama Canal enterprise of M. de Lesseps was the most scandalous bankruptcy of history, not excepting even the South Sea bubble. It had been born in 1879 in the greatest international congress of engineers ever assembled. Some of the foremost authorities living had indorsed its prospectus. The nation poured gold in an ever-mounting stream into the execution, and after nearly ten years of splendid battling, desperate courage and dauntless endurance, combined with hoodwinking, manipulating and blind gambling on the impossible, the enterprise crashed, and the faith and hope of the proudest people in Europe were undone.

Americans Begin the Work.—This story was still warm when we took over the canal project. The linking of the oceans was an idea to stir all aspirant blood, and we were lifted into elation that its achievement had been reserved for America. We buried deep under our feet the skeleton of the sinister past, picked a popular cabinet member for leader, put the project into his immediate personal charge and, under his white plume, pushed valiantly to the front to press the waterway to completion.

The deity at the portal of the old project had been Janus-faced. Aspiration and courage in the many had fronted the world; concealment, guile and subterfuge in the few had backed it. But the few were in the fateful seats, and they weighed the balance down to destruction. It was the malevolent genius which had lured $256,000,000 out of the trusting French populace and had dragged them to the Tartarus of the debacle. We determined one thing absolutely—the deity presiding over our canal would have no Janus faces; there would be no covering of nakedness, no concealment, no juggleries of facts; our temple would have no dome, it would be open to the heavens, and frankness and truth would be its radiant archings. And this was well, for the Panama project was anchored in public confidence and public trust. Its roots were in moral soil and its life force was drawn from the deep well-spring of faith. The people were the friend and the support of the waterway, standing beneath and making it possible, and their confidence could exist only as it was grounded in candor and perfect truth.

The eighty millions of Americans indorsing and paying for the Isthmian waterway were doing so in faith, first, in the technical fitness, efficiency and trustworthiness of the engineers in whose professional verdicts the canal's destiny was pivoted, and next in the general truthfulness and responsibility of the management executing those verdicts. It expected that the technical decisions when delivered would be safe and worthy and final, and that the direction would be strong and open before the face of men. The one fatal policy which they did not anticipate was that where engineering mistakes were made they were to be condoned and covered; where management mistakes were made they should be disguised and continued. If disappointments loomed straight before, they expected this cabinet leader and his assistant sponsors themselves to announce the facts, that the public might know and prepare for them. They did not bargain to be led on in a full tide of sanguineness straight to the edge, and then be precipitated into the reaction of sudden disclosures.

Facing the Truth.—The advocates of the waterway will seek, of all things, to prevent this. That the public shall know the truth must be their first concern. Had the French people been kept informed at each step of the dubious way regarding the Panama situation there would have been no

debacle and no enforced abandonment of the canal enterprise. Safer and saner counsels could have been called in and the enterprise could have been checked in its reckless course. But it was not, and into the pit went the millions of the French peasantry.

The true friends of the Isthmian project want this canal; they desire that it shall get built. They believe that since this possibility lies in the faith and trust of the public, which must furnish the money, the public must be in possession of the truth, the full truth and nothing but the truth.

The individual most concerned in the success of the Panama enterprise is the President. Of all our national interests it is the one directly started under his administration, the one to which he had given resurrection. Therefore, of all Americans his claim on the Panama Canal is first. That it shall be conducted in honor and be brought to success concerns him vastly beyond any other living man. The President has felt his matchless privilege and its proportioned duty. The Isthmian waterway has been his deepest concern. In the nature of things the project has had to be confided in details to other hands and other minds. Out of their offices he wove his opinion and created his policy. He was not a specialist, so he must depend upon specialists for the crucial judgments; he was not a constructor, he must depend upon executives for canal building. He picked his adjutants and to them intrusted this work—this greatest public achievement ever assayed by man.

How have they served the American people and the American President? Are they giving trusty engineering to found their waterway upon? Are they giving wise methods to execute it upon? Are they giving right costs to deliver it upon? Let it be known.

CHAPTER I.

FINANCES—DEFICITS.

The first factor of the Panama situation which shall be brought to the balance for the weighing is the finance.

This is gauged, in the main text, as of January 1, 1907, and is brought to November 1 of this year by supplementary insertions where pertinent. The intervening ten months have but verified and accentuated the conservatism of the conclusions.

Congress has appropriated for the waterway $145,000,000. The official estimate for the 85-foot six-lock project was roundly $140,000,000 exclusive of Sanitation and Zone Government. Of this Jan. 1, 1907, $40,000,000 have been expended, and the call has been issued a second time for $25,500,000. With $25,500,000 as the yearly rate of call, eighteen months later but $67,000,000 will be left to call. This must serve the entire expenses during the nearly seven years then remaining of the estimated construction time. It is, therefore, self-evident, mathematically that were the rate, when the work is in full swing, never above the past annual rate of call, the deficit would still amount to more than $100,000,000. A hundred millions of deficit in straight sight, and the work still only in the stage of preparation! Has one word been spoken by those in authority of deficits? Has not everything regarding the canal been reported with the highest approval and optimism?

This sum of a hundred millions is based upon a rate of money demand on Congress supposedly no greater than that obtaining in the past. If this rate is increased (as it has been in September, 1907, by eight millions), manifestly the deficits must increase also. There has been an impenetrable silence regarding the finances and an enigmatical cross-firing regarding the technique, but much heralding of what "we are about to do." So the bases for certain estimates are at hand, and we can roughly outline some of the accretions for the deficits. The amounts will be significantly gauged or forshadowed as the import and content of each element is revealed.

The Commission report gave 25,000 men on the payroll in the spring of 1906. On his return from the Isthmus in the autumn, the chairman stated the number as around 30,000 then. The message of December, 1906, put the average force for the last ten months as 26,680, and officially announced that 25,000

additional were to be put on. The labor contingent was to be therefore, at least doubled.

Men, to live, must have quarters, barracks, messes, hospitals and all the addenda which go with living. It has taken three years and a goodly share of the expended $40,000,000 to provide the varied quarterings for the 25,000 or 30,000 men installed in 1906. The official "Canal Record" of October 16, 1907, publishes Col. Gorgas' Report. It states "slightly over 41,000 appeared on the rolls of the Commission in September, 1907, against 28,000 the year previous." The full labor roll is used in American *health statistics.* The Chairman reports that September 30th, 1907, there were working, 29,845. This is the factor of "effectives" used as the French basis of health statistics. During the month, 783 were brought to the Isthmus. Some 26 per cent. were therefore on the rolls but not working. How much more time and money must be consumed, to house, hospital and equip for duty a duplication of the 1906 force? We had at our beginning a number of residences, barracks, hospitals, stables, hotels, etc., which had come to us from the French, and which needed but a partial expenditure for restoration. Ancon Hospital, costing over $1,000,000, is still our chief dispensary; Colon and Toboga still supplement it. The Administration building does service; Cristobal bears testimony to past fitness, and the Folies Dingler redeem their name to honor. Upward of 2,000 buildings were taken over. These have all been credits, keeping down the costs of providing for the first 25,000. The best and costliest of those buildings are occupied. The second contingent's provision must be built more largely, de novo; hence the cost must be increased in an amount represented by the lesser utilization of the French purchase.

Some addition to the $100,000,000 of deficit, therefore, lies over against the domiciling, the mess quartering, the hospitalizing, etc., of the 25,000 additional men that the message stated were to be employed.

The second addition to the deficit is the further wage account. The labor roll, inclusive of the wage roll of the Panama Railroad on improvements for canal service, January, 1907, is approximately $1,000,000 a month. Thirty-five miles of the Panama Railroad are to be removed and rebuilt upon higher ground, so the collateral expenses of the railroad continue. Nearly twenty per cent. of all the employes at the Isthmus are in the service of the Panama Railroad. One million a month is $12,000,000 a year, and $96,000,000 for the eight years of esti-

mated construction. Ninety-six million dollars must be provided in wage for one-half of the labor force which is to be engaged—and $40,000,000 out of the estimated $140,000,000 gone already! Deducting the wage for the 1906 contingent during eight years, there is left of the estimated fund the munificent sum of $4,000,000 to pay for material and supplies and everything else needed to construct the canal.

If January, 1907, the force is to be doubled in order to complete it in eight years, the wage factor must rise accordingly. Doubling the labor roll must somewhere approximately double the wage item, and $96,000,000 must become $192,000,000.

One hundred and ninety-two million dollars are to be paid out in wage alone, if 50,000 men are to be at work in Panama—$192,000,000 for the eight estimated years. The Sanitary Reports give the total number of employes in July, 1907, as 38,298 in August, as 40,443, in September over 41,000. So the contingent is well on towards its doubling which must come when locks and dams are under construction. Has the Secretary of War invited the attention of the American people to the deficits involved in the payrolls? It is the Government's 85-ft. project, executed by the Government's selected method, that is calling for such excessive numbers at Panama. One group of its engineers advocated another type of canal—a sea level, to be executed after the self-same manner. It had twice as much digging to be achieved, and twice as many men to be impressed, or twice as long a time to be given for execution. America, in gratitude for escaping Scylla, ought perhaps to be willing to dash upon Charybdis, but there was to have been no Charybdis. It was safe sailing in an open sea that was promised, and $140,000,000 was to cover the voyage. Has the Secretary of War, who had Congress so carefully instructed as to the facts of the vast labor force, the stupendous cost and the long years of delay inevitable to the sea level—has he done the same by the 85-ft. design?

The total prism excavation, allowing grace of official measurement, was to November 1, 1907, 14,376,677 cu. yds. and about 69½ millions of money had been disbursed on vouchers and pledged for unvouchered commitments, aside from the 50-million purchase price.

The French in ten years at a cost of 256 millions achieved 2/5 of their small waterway; we in four years (Nov. 1907) have achieved one-ninth of our very much larger waterway. Excavation alone has been thus far undertaken and excavation in the

upper easier formations; the underwater rock, the masonries and the dams are unessayed.

This 47 miles of Isthmus has taken, November 1st, 1907, over $335,000,000 of French and American capital or the appalling average of $7,000,000 per mile. By July, 1908, the American expenditure will equal half that of the French and our work is but fairly begun.

The fundamental theory of this 85-ft. canal and its execution will break the nation's treasury sorely on the wheel, if it be not broken itself first. The root of the Panama problem lies here—is land dominion or water dominion the goal in a waterway? Shall the land width to be dug and conquered be the greatest or the least possible? Shall water sovereignty be established at the latest or the earliest possible?

There is a way, simple, natural, cheap. Under it, by the building of three low dykes, no higher than those that impound the reservoir of Central Park, in one year, and at a cost of less than $1,000,000, the land width of the Isthmus can be reduced from the present forty-seven miles to less than sixteen miles. Forty-seven miles to sixteen miles—the distance narrowed to one-third. Would not this auger a living chance for the canal? Would not this hold some valid promise and some possibility of cut costs and cut forces? A year later, by impounding but fifteen feet of water at Gatun, the land width can be reduced to the distance between Pedro-Miguel and Obispo—around seven miles. Forty-seven miles in two years reduced to seven, the land width cut to approximately one-seventh—the problems, the expenditures, the execution confined to this narrow pass between the hemming waters, what rescue and salvation does it not guarantee? A small force at Mindi, Gatun, Pedro-Miguel and Sosa, building the single isolated locks and low dykes, these would represent the whole canal construction outside the defile. And for it an advancing water platform would secure to the construction that ideal of execution here, the minimum of land plant and the maximum of water-borne machines. Are not the simplifying and the elimination which this system supplies self evident?

CHAPTER II.

PREPAREDNESS.

Next in the count of additional deficits comes the question of preparedness. The special message announces the close of the long preliminary period and the entrance upon the second epoch—that of execution.

The vast expenditures of the three first years have been justified always on the plea of preliminary outlay: "Getting ready, getting rightly and fully ready." This plea has been the laconic vindication set like a stone wall against every question. Now the incubating has been fruitful, and the announcement is made officially that the preliminary phase is at last over and that we enter the second stage—that of actual execution. To the Senate probings the same explanations were tersely vouchsafed—the great outlays were warranted; they were made once and for all; they were a finality, hence it were wise that they were made fully and well. But this was of the past, the large investment was closed and supplies were in hand to push the work at white heat to achievement. These claims were reiterated as recently as last December, in the opening paragraph of the Commission's report. It reads:

"During the year the first stage of the canal work, that of preparation, has virtually been passed, and the Commission finds itself in a position to enter upon the second stage, that of actual construction of a lock canal at an elevation of eighty-five feet, authorized by Congress June last.

Emphatic testimony to the thoroughness with which the preliminary work has been done was borne by the Senate Committee on Interoceanic Canals in its majority report, made to the Senate on May 17, 1906, after an investigation which extended over a period of six months and included every detail of the work and every act of the canal officials. In that report the Committee said:

The work authorized by the Spooner act has been initiated, and extensive preparations for a rapid prosecution of it have been made. The Canal Zone has been placed in a satisfactory sanitary condition, adequate shelter for the workmen has been provided, hospitals of very large capacity have been made ready, as is evidenced by the opinions of experts who have testified before the Committee, and we are fortunately now in possession of a vast array of figures affecting the prosecution of the undertaking that have not until now been available. This is due to the fact that the preparatory work has for two years been prosecuted with patient, intelligent judgment and earnest effort by those intrusted with the direction and supervision of the work."

Let us examine these statements that the Secretary's trusted subordinates published in their most authoritative public record—the report—and which they have put into the mouth of the Executive, and, sponsoring which, they allowed him to go before the country in a message. Had the Secretary of War no responsibility here, or the chairman, or the Commission? What kind of facts have they given him? The claims will be analyzed. If they shall prove to be as deluding as they are deplorably untrue, will the judge deem the equivocation accidental or deliberate? The 1906 report of the Isthmian Canal Commission is signed by the chairman only. His colleagues were, under the authority of Congress, coequal, but they are ignored; he signs alone. The Chief Engineer and the Governor are allowed appendices, a sort of codicil to the will, that is all. The statements of this preamble must, however, have had the approval of the chairman's colleagues, since they are silent. They had the sanction of the Secretary of War, since he does not correct their allegations and assumptions; they had the indorsement of the then Chief Engineer, since we heard no voice in protest.

Has the "first stage" in canal work been "virtually passed"? Are plant and equipment enough, or anywhere nearly enough, provided for executing the work? Begin on the Atlantic end. There are on hand January 1, 1907 two dredges, both patched-up relics from the jetsam of twenty years ago. There are on order:

For Colon—Two dipper dredges, neither of which can reach the 45-ft. depth planned. One has been a year and a half building and is not yet ready; the other is just ordered and will be at work in another year—perhaps. There is on order a self-loading hopper suction dredge, which may be ready to begin operations in eight or nine months. (It began as reckoned in September, 1907). It cannot discharge its hopper contents ashore, nor work in the upper half of Limon Bay, because the material there is too light to remain in the hoppers and will flow overboard about as fast as it is drawn up by aspiration and discharged. Besides, the upper half of the bay, unprotected by breakwaters, is too rough from the constant on-shore trade winds for such a vessel to be safely operated.

The chairman, January, 1907, proposes to order two smooth-water suction dredges. These may be delivered, if on contract time, around March, 1908, some months hence.

This is the status upon which the chairman assuringly announces that the Commission "finds itself ready" to excavate

the Atlantic terminus. Is it ready? Is this all it intends to order? How, then, is it proposed to drill and blast and lift and distribute the unknown and misreckoned millions of cubic yards of indurated clay-rock between Mindi and Gatun? Has it any drill-boats, any modern rock breakers, anywhere, or on order? No, not one. Enough to meet the requirements of this 85-ft. scheme will cost a million of dollars and will take from a year to eighteen months to build, equip, install and organize. The clay-rock will have to be stripped of 20 to 30 ft. of overlying swamp, and there is no dredge or other machinery there to attempt it, or likely to even start before the spring of 1908.

Is, then, the first stage of preparation for the harbor entrance—or the three-mile approach channel to Gatun passed? Evidently not. The curtain is not yet rung up; the scenery is not even in place.

Next we survey the narrow, hog-back ridge whereon is to be perched the mile-and-a-quarter-long double staircase of three great concrete locks. Where are the locomotive and cantilever cranes, the forest of derricks, the compressor, drill and channeling plant, the power station, the excavating mechanism, the spoil distributing devices? Where the cement works or the crushers, the screens, the mixers, the conveyors, the tracks and all the vast array of mechanism needing another million dollars or more to get ready to excavate for and build these locks? If these accessories were all thought out and on order to-day they would take, for installation, over a year.

The "Canal Record" of September 18, 1907, states that the preliminary studies of methods here have not yet been completed —let alone approved.

Next, the plant wherewith to build the mountain of the Gatun dam—where is it? Where are the fleets of barges, tugs and quarter boats to transport the spoil to Gatun? Where are the relay stations, the engines, pumps and pipes to force to untried heights and rehandle 30,000,000 tons of dredgings, as the minority supported by the Commission propose? The Lake Superior ore is not dug to make the pig iron for the castings, and the machine is not invented. Where are the trestles or the tracks from which to dump the millions of tons of rock from Culebra to make the ridge-like toes of the dam? Where are the machines to excavate the spillway site or open the old French canal, dig the laterals and clean

out the growth-filled sloughs of the Chagres, which are needed to afford water access to the dam site? All this equipment will take very conservatively four or five million more dollars.

Next, where are the dredges to excavate the lake bed above the plane of 40 ft. between Bohio and Obispo? When, pray, do they start the "second stage, that of actual execution," of this section wherein there is enough earth and rock to fill New York from Canal street to the Battery and from the Hudson to the East river, all to the height of a tall man's head? Eight years hence is the soonest, if dredging is to be employed as announced by the "experts," or whenever the dam is ready and there is 50 ft. of water against it—be it eight years or eighteen.

Next we come to the central mass. Here the chairman "is ready," surely. On the recent momentous inspection, strangely companion to the triumphal junket of de Lesseps about a quarter of a century ago, and sending the same cheer worldward, there were at the end of three years twenty-one steam shovels in the shops at Empire, in various stages of repair or assembling. There had been installed on the terrace galleries of the great trench, after a commendable effort to make a showing—twenty-six. There were actually counted at work by a trained observer, as noted in the engineering journals, just—eight. We venture to ask, Were any at work next day—Saturday? Were more than five able to work on Monday? Was one over-turned? Were eight partially buried in the sea of mud? The Culebra—"It has been dug 200 ft.;" but we did not do it—it was the French. The "Canal Record" of October 2, 1907, discloses that no greater depth has been yet attained. "It is as wide at its yawning top as it is meant to be," but we did not do it— it was the French, the French, with the toy excavateurs and the French liliputian cars. Part of it owes grace of being to the thousand Hollanders of Contractor von Hattum, 800 of whom sleep in Mount Hope and the catacombs of Panama, happier fated than the 200 who returned to their homes in the Lowlands to go into insane asylums. (All our four years' work has been the easier widening and the Cucaracha mud-glacier which the French fought for twenty years is more menacing than ever.)

At this opening of 1907 the chairman—there is no Commission —has twenty-six of the best steam shovels that money can buy, with the best picked men that could be gotten out of this wide

Union to run them, and, in combat with the rain, the mud, the heat and tropic environment, the machines do one-fifth as much as they would do in northern latitudes. A claim has been made of as much as 10,000 cu. yds. per month for the average of Culebra output in 1906. The steam shovels in the Culebra are doubtless very impressive—when they work. The French left some imposing results and toy plant—we have some imposing plant and toy results.

Next we pass to the Pedro Miguel and Sosa staircase of the locks. Where are their derricks and cranes, crushers and grinders and mixers? Again, not even ordered, and the plant will require a million and a half dollars and will demand fifteen months of time.

Where are the equipments, the dredges and the plant to build here the lordly dams, containing over 12,000,000 cu. yds., whose material is to be lifted over 80 ft. and whose volume equals four of the greatest of Egypt's pyramids?

Last, we view the readiness in Panama Bay. The old French dredge that has been fighting the endless deposit of sand from littoral drift, for years trying to keep open access to the La Boca pier, will now enter its "second stage," and in a year or so the one hopper machine ordered will round Cape Horn and come to bear it company, as will the other dipper dredge that at high tide will not come within 20 ft. of touching bottom. This is preparedness at Panama! How many unreckoned millions are to be still expended for adequate preparation?

(The foregoing chapter was written in January, 1907. Ten months later, November 1, 1907, the excavating plant has been augmented by rehabilitating two old French dredges for the Colon Division and one for La Boca. Twenty-two more steam shovels are on order in addition to the 1906 complement of sixty-three.

The increased output during last half of 1907, gratifying as it will be generally regarded, is almost wholly due to bringing the dredge fleet into service and employing it on the resilted portions of the old French cuttings and the easiest digging in the approaches at Colon and La Boca—where a limited amount of soft material makes a large but illusive showing of valuable achievement.)

CHAPTER III.

Deficits Submerged in Material and Supplies.

Further addition to the hundred millions of deficits are submerged in "Material and Supplies." What expenditure is probably involved in these items? There are two sources for getting a lead here. One is the cost to the French of "materiel" on their much smaller canal; the other the cost of materials and supplies to the Commission on their own project thus far.

It must be prefaced regarding the French that the type toward which they were hewing in these earlier years was a sea level, and their problem embraced excavation almost exclusively, not the material and supplies incident to the great locks, gigantic dams, etc. It must be further prefaced regarding the Americans that the "materials" needed for incorporation into structures (except as to quarters for men) during the first years have been slight, because there has been almost no canal construction. Permanent docks, locks, dams, spillways, etc., have been hardly even started. The past call, therefore, cannot be considered more than an intimation of what must be the demand in the coming time, as the construction runs its course. Excavation has been thus far the only canal work undertaken, and excavation in the upper strata; the submerged rock, the indurated clay-rock, the masonries of locks and dams—these all await the future. The work is still scarcely begun. Its preliminary expenses give, therefore, but a herald of what will be needed when execution is at the great flood tide, imperative, if the waterway on this plan and with these methods is to be completed in eight more years.

The report of M. Flory to the French Chambers (page 58, Panama Rapport), under "Material et habitations a fournir par le Compagnie" gives the French pace.

The French management furnished the plant, houses, barracks, repair shops, hospitals, etc. The first two years were to be the "period of preparation" and the second was styled the "period of execution." The price of work in the Couvreux and Hersent contract, the first and lowest one made, was to be determined under a special committee, which should decide unit costs. During the organization period Couvreux and Hersent were to have 6%. A limit of $102,400,000 was then accepted by them as an overhead figure for their part in executing

the Canal, and this amount was allocated to the work by the French company. When they renounced their contract, others were made—over a hundred, great and small, in which the corporation undertook what M. Flory recounts.

What was the actual yearly outlay of the company to meet its part in the obligation on the small channel, involving no great masonry locks and spillways? He writes: "The Panama Company was obligated to furnish to each contractor the important (major) plant, also the houses, barracks, etc. These engagements were made, it may be said en passant the origin of such incessant claims on the part of the contractors and claims of such great amounts that in case of completion of the works it is not practicable to fix upon what would have been its actual probable expense. We have not been able to ascertain the sums really paid for the same items before the month of July, 1886, but after that they are as follows" (5 francs equal $1.00):

"In the course of 1886-1887, $2,916,138, one year.

In the course of 1887-1888, $4,115,236, one year."

It has been taken for granted, in the great complacency, that we would do better, but the latest Isthmian report gives actual figures. One finds that in this, as in nearly everything else the 1906 Commission has gone the gait. Reproaching the extravagant French, they have outdone them four-fold.

Material and supplies have been bought already to such a sum that the outlay is over $800,000 a mile to be dug (October 1, 1907 it has mounted to $1,100,000 a mile to be dug)—and quantities of plant, lock and dam materials, mechanisms and supplies remain yet to be provided, before the stage of preparation can be at all reckoned as passed. As to certain important costly elements, it is not even begun. If the State of New York had bought material and supplies at only the past Panama rates for its barge canal, the getting ready would have required to-day nearly twice the whole $101,000,000 which its entire work is to cost. This Barge Canal is ten times as long as the Isthmian waterway. It extends from Albany to Buffalo, with branches. Twenty millions in contracts have been awarded at 10 per cent less than the engineer's estimates. It is to have some twenty-six locks. The 85-foot Panama project builds six. The Isthmian Commission had ordered or expended at the beginning of 1907 $20,000,000 for material, supplies and plant, and this sum is but the dipping of the flag. The horses are only off. October,

1907, these expenditures and commitments total over $30,000,000.

An analysis of the Isthmian report discloses that prior to April, 1905, the actual disbursements for material and supplies were not large, though some orders had been given. The Walker Commission was in power, and Mr. Wallace was Chief Engineer. But the pace was deemed too slow, and the next Chairman was called to the "free hand." The free hand was a full hand and no questions asked. Wholesale requisitions really began in the administration of the Executive Committee starting April 3, 1905. In July, 1905, Chief Engineer Stevens was inducted into office. It is, therefore, apparent where the primary responsibility lies. When he took hold there had already come a complete congestion of the wharves of Colon with the material and supplies already purchased. In his testimony before the Senate Committee he gave a vivid picture of the resulting conditions. He stated that 3,000 cases without names or apparent destination were gathered on the Isthmus and were forwarded by steamer lines down along the Pacific Coast in an endeavor to find consignees. After herculean efforts, the boxes and cases remaining were distributed along the Zone, and in some instances in warehouses erected especially for their reception. The largest of these was at Mount Hope, and it was a suggestive location in view of the character of certain of the purchases. In the spring of 1907 this warehouse with its contents charitably burned.

When the Burlington & Quincy took over a railway which it acquired in 1878 an inventory of the tickets and stationery laid in by the general passenger agent showed that the stock was sufficient for 324 years. Since this principle was found to have gone through all its administration, it is small wonder that the road went into bankruptcy.

From July 1, 1905, when the late Chief Engineer took hold, until June 30, 1906, to quote only one year, there were continuously employed in the department of material and supplies a very large working force, as per the following schedule:

July 1905, 1,750; August, 1,636; September, 2,107; October, 2,281; November, 1,831; December, 1,443; January, 1906, 1,585; February, 1,493; March, 1,670; April, 1,303; May, 1,356; June, 1,356.

During this period from 8 per cent to over 16 per cent of the mean number of canal employes working were used to receive, store and reship the immense quantities of ma-

terial, etc., arriving at the Isthmus, out of the $20,000,000 worth paid for and on order. It would take months of expert work to go through these purchases and separate those really needed from those not needed. An analysis has been made of but a few of the requisitions issued, ordered and filled. A river of money has run under the bridge and huge sums have gone into materials whose real value to the project is a fit subject for investigation. We instance some of these only, and ask if these are typical of the requisitions sanctioned:

Serial No. 207 of April 15, 1905, bids for which were opened May 12, 1905, in class 12, a requisition for 104,000 pairs of butt hinges, and again in Serial No. 289 of November 20, 1905, bids for which were opened December 8, 1905, we find in class 28 nearly 84,000 pairs more of the same article, making a total of 188,000 pairs. There were also purchased on open purchase requisition by the New York agent of the Canal Commission prior to April 15, 1905, about 60,000 other pairs of T-butts and strap hinges.

One pair of hinges is all that is necessary to one door, so that provision has been made for about 250,000 doors. This is a devotion truly to the open door—to 250,000 of them.

Again in Serial No. 289, as above mentioned, hinges were specified as "bronze plate on steel." The difference in cost between these and the plain steel for the quantity specified is approximately $5,000. A costly indulgence!

Examination of the report of the Chief Engineer for 1906 shows that 1,018 of the old French buildings have been repaired and that 204 new ones have been constructed, a total of 1,222 buildings. Among all our literary friends writing with such intimacy of the Isthmian Canal, none of them have remarked that each house has on the average two hundred doors. July, 1907, there were 2,919 buildings of which 1,270 are repaired French structures, 678 such buildings remain to be repaired, 971 are new. All this has cost $8,255,837. There were October 2, 1907, so the official organ states, 652 painters at work, who in one year used 530 tons of "lead" alone. One man in fifty at the Isthmus is a painter.

In Serial No. 207, class 11, of the same dates as above, there are called for 117,500 steel set-screws in quantities of 2,500 of each size from three-eighths to one inch in diameter, and also 130,000 hexagon cap-screws, in all sizes from one-fourth to one inch in diameter. Such a stock of

set and cap screws could not be found in any factory or warehouse in this country. In fact, many of the sizes have had to be made up especially.

Exactly what use there could be for such a quantity of this material it is hard to imagine, especially as there is very little machinery indeed being built on the Isthmus.

In Serial No. 216 of April 19, bids for which were opened on May 17, 1905, we find specified in all 100 rail saw machines of the Bryant type. These are small machines operated by hand power, using circular cold-cutting saws. They are needed by section gangs and track layers. This number would allow two machines a mile on the Panama Railroad. The great railroad systems of the United States do not ordinarily have more than one machine of this type to every third section of five or ten miles. The approximate cost of this purchase was $10,000, over ten times what the usual practice would have warranted.

In the same Series No. 216, in class No. 28, were specified 70,992 files. These were of all kinds, including different shapes and cuts. They took in practically the entire list from beginning to end. The quantities on the items specified were away out of proportion to any commercial practice, as the same quantity of all lengths were ordered. Ordinarily where 100 dozen of 10, 12 and 14-inch files are specified, twenty-five dozen of 4 and 6-inch are ordered and ten dozen of 18-inch, and usually a larger quantity of 8-inch than of any other. The enormous size of this and other file orders makes one wonder what unwonted office files are to serve on the Isthmus.

Three orders called for 19,900 faucets; another group of requisitions for 5,076 rakes, 59,276 locks, 14,420 more hinges; 6,000 rubber valves and 16,000 metallic valves of every size; still another group called for 709,620 bolts, 854,300 pounds of nails, 3,521,312 screws, 326,876 rivets, 2,338 pulley blocks.

Then there were handsaws, thousands and thousands and still more thousands of handsaws, 26 inches long, and thousands upon thousands of hammers and extra handles and wrenches; and every other item that is listed in the great catalogues (some of them a thousand pages long) which are issued by the manufacturers and supply concerns all over the country.

While it is not now maintained that any article except the steamers has been bought at a price higher than should

have been paid for it, nevertheless to purchase numberless things that cannot be required or used is just as censurable. The Isthmus is the land of rain and rust, and every rod bears testimony to the rapid destruction which nature herself effects. The administration of the French company should have been lesson enough on this. It bought stupendous quantities of plant and material, which were sent to the Isthmus and were never used, and never could be used and never were wanted. The Panama Canal can have no enemies more real than men who make and men who sanction wholesale purchases of materials which are not needed, or which are not adapted to or wanted in its construction:

The chairman continues in the 1906 report as follows:

"The total stock of materials and supplies on hand June 30, 1906, in charge of the division of material and supplies, which have been purchased since the United States took charge of the work on the Isthmus amounted to approximately $1,400,000. During the month of June, 1906, the division of material and supplies disbursed materials to the various departments to the value of more than $1,200,000, from which it will be seen that taking that month as a basis there was on hand on June 30, 1906, in charge of the division of material and supplies an average of only about thirty-five days' supply of materials."

Here then we have the authoritative American gauge before the second stage is begun, $1,200,000 monthly. There are immense quantities of raw materials, cement, sand, steel, etc., not yet supplied and to be required for locks and dams and spillways. At this given rate, presumably six months later $7,200,000 have been issued. If in the eight fat years of the "second stage, that of actual construction," this past rate, which this Chairman himself assigns, were maintained, he would expend for "material and supplies" for the Panama Canal $115,200,000 more.

It is necessary to incorporate some statistics taken from exhibits of this last Isthmian Report, in order to see what the preparation such as it is has been in relation to the purchases of the Commission. This is a guide to their presentation of the actual status, and it is one measure of their work under the direction of the Secretary of War.

The items are segregated from the mass in which they lie obscurely buried.

Summary for fifteen months ending September 30, 1906:

Expenditures, exclusive of materials, etc.	$11,235,993.93
Materials charged and issued	7,222,397.42
Materials paid for and not charged to expenditures	4,518,651.83
Total	$22,977,043.18
Materials, etc., paid for	$ 4,418,651.83
Materials, etc., on hand	3,785,454.16
Sum apparently paid out for material not yet delivered	733,197.67

Summary from beginning to September 30, 1906:

Material issued	$ 9,352,210.15
Steamers bought	1,312,872.67
Materials, etc., on hand	3,785,454.16
Advance payments	733,197.67
Total	$15,183,734.65
Materials ordered not paid for June 30, 1906	4,797,595.21
Say	$20,000,000.00

As a part of the $145,000,000 authorized by the Spooner act, appropriations have been as follows:

June 28, 1902, starting sum	$10,000,000.00
December 21, 1905, emergency account purchases	11,000,000.00
February 27, 1906, emergency account purchases	5,990,786.00
June 30, 1906, annual appropriation	25,456,415.08
Total	$52,447,201.08

The commission receipts, (page 118 Report 1906,) have been $53,496,533.45. This is exclusive of the original purchases from the French company and from Panama Republic, 40 and 10 millions respectively.

The disbursements to September 30 are:

For material and supplies	$15,183,734.65
For all other items	12,288,216.72
Current assets	26,024,602.08
Total	$53,496,553.45
Roundly	53,500,000.00

On June 30, 1906, before the appropriation then accorded, there stood against the net assets of $5,613,879.55 liabilities totaling $6,646,814.35, leaving a deficit of $1,032,934.70.

Against the current assets of September 30 there stands: Liabilities per exhibit D (p. 12) $1,234,856.27 and unvouchered accounts to an amount unknown, and not reported anywhere.

If we take the June 30 report as a guide, it is probable that the net assets on September 30 were about $20,000,000 and the financial exhibit was roundly as follows:

Material and supplies paid for or on order	$20,000,000.00
All other items	12,288,216.00
Net assets September 30, 1906 (of which $5,000,000 or more is spent January 1, 1907)	21,211,784.00
Total	$53,500,000.00

Of these sums, of the $32,300,000 of money paid out, or obligations taken to September 30, 1906, there is charged to the canal construction (p. 125) for the fifteen months ending September 30 but $3,099,537.50. Of this there is charged to excavation only $1,233,430.86. This is considerably worse than the French proportion, and the ratio of "work done" to "money expended" in their schedules was the handwriting on the wall. The total outlay for actual canal construction since our beginning is $3,793,829.83. It is amazing, this—but we are quoting the report, and the Chairman of 1906 is the voucher.

During the last fiscal year (1907) the monthly disbursements of the Division of Material and Supplies has been $750,000 or 9½ millions. At this rate the coming eight years would consume $76,000,000.

From Numbers 1 and 2 of the "Canal Record" the following table is derived showing the directions of the various expenditures for the first six months of 1907.

TABLE.

	Jan. 1, 1906.	July 1, 1907.
Sanitation and Zone Government	$4,381,089.80	$5,791,457.03
Construction and Engineering	9,729,554.98	15,594,834.17 (Buildings, 8,255,837)
Plant	12,138,852.17	18,484,300.74
Material and Supplies	3,449,022.96	3,649,655.13
Loans to Panama R. R.	765,480.00	1,631,257.34
Advances to Panama R. R.	1,683,646.90	1,826,683.50
Due from Individuals and Companies, to go to U. S. Treasury	1,020,008.72	1,950,952.28

July, 1907.	Receipts.	Expenses.
Revenues and Appropriations.....	$102,662,295.77	$100,489,816.11
Due I. C. C.....	716,976.36	
Unpaid June Pay Rolls, etc.....		3,252,655.11
	$103,379,272.13	$103,742,471.22
Deficit June 30, 1907.....	$363,199.09	
Cash Assets	$2,172,479.66	
Pay Roll unpaid.....	3,252,655.11	

This exhibit discloses that Sanitation and Zone Government in six months cost $1,410,367.23. In eight years this item at such a rate will total 22½ millions.

For Construction and Engineering the six months' total is $5,865,279.19 and for Plant, $6,345,448.57.

Not a line tells of the "unvouchered accounts" June 30, 1907, but they were $7,750,000 January 1, 1907.

There was, June 30, 1907, exclusive of such engagements, a bookkeeping deficit of $363,199.09, but the payrolls were $3,252,-655.11 and the amount of previous revenues and appropriations left was but $2,172,479.66—a real deficiency of over a million dollars which must have been drawn from the appropriation of this fiscal year.

The operations of the imperium in imperio afforded by the retention of the corporate form of the Panama Railroad, are indicated in the "loans" and "advances" totaling June 30, 1907, nearly 3½ millions. Besides this, two millions were "due" from individuals and companies mostly the "railroad and other interests engaged in allied work," an increase of nearly a million in this item in six months.

On the 18th of August, 1907, the Chairman and Chief Engineer requisitioned from the President four extra millions for labor and four more for material beyond the grant of Congress. This makes a total for the year ending June 30, 1908, of over 35 millions and leaves but 57½ millions of the original estimate to finish the canal. If this latest demand be the rate of call for even eight years the requirements are *over 280 millions more* and the deficit in sight mounts to *222½ millions aside from interest and delays and uncounted items.*

If the 85-ft. canal can make but this showing what would have been the record before the sea level excavation had been achieved?

Has the Secretary, or the Chairman, or the Chief Engineer, or the Commission given any warning of the great additions to the deficits submerged in "materials and supplies?"

CHAPTER IV.

Time of Execution.

The next element of accretion to the deficits is involved in "Time of Execution." Nine years from January, 1906, were given for the 85-ft. Canal; one year passed and a dash for the pole began the first of the month of January, 1907. When we allow the amplitude of eight years, ships are to pass the Isthmus December 31, 1914.

A former chapter set forth the condition of utter unpreparedness, which has rung out the old of the "preliminary" and rung in the new of the "actual execution." The plant on hand at the Isthmus has been detailed—it consisted virtually in mid-November, 1906, of fifty-two steam shovels. Of those which in the three years had been erected in the shops at Empire, twenty-six only were in place at Culebra. Two were at Gatun and one was at Pedro Miguel. On incident collateral work, one was at Mindi and one at Miraflores. The rest, twenty-one, were still in the erecting and the repair shops. These thirty-one shovels, together with the engines and tracks to serve them, and three very small dredges, represented the plant in place ready to work. Of the sixty-one shovels ordered (report of 1905), nine were erected in 1905, thirty in 1906. From June 30 to November 16, 1906, four and a half months, thirteen only were put together, making fifty-two in all. In July, 1907, there were 63 shovels on the Isthmus, 39 on the average were, in September, operating on Culebra Division. Some are engaged in collateral work, such as preparing the roadbed for tracks incident to the transport of material. Twenty-two more are reported on order for gradual delivery. There remains still an allied project whose vast scope is little realized. The Panama Railroad for a distance of thirty-five miles is to be abandoned and a substitute line is to be built high up the canyoned slopes. "The construction of the Canal will necessitate building thirty-five miles of new road at an estimated further cost of $3,700,000. It is thought that not a dollar of this can be saved, though when the Canal is finished the railroad will probably be almost useless." Thus epitomizes one of the "85-ft." advocates. "Not a dollar of it can be saved!" It is all part and parcel of the needlessly high-level Canal and the superfluous sacrifices it entails. But this is another story. The utter inadequacy of

the $3,700,000 is also a matter for later analysis. It is sufficient to point out here that this vast work is planned to be done and that steam shovels will be impressed in its new cuttings. One fill alone in Lake Gatun with stable slopes has the handsome total of between 7,000,000 and 10,000,000 cubic yards.

All this railroad changing and grading and tracklaying are incident to the 85-ft. design and its execution. But incidental work and its involved plant are aside from Canal digging. The rate of output in the cut depends upon the number of machines available for the cut, not available for something else. To this direct service, therefore, only a proportion can be assigned.

For the water excavation January, 1907, there are on hand ready to work, three small machines—relics of French heritage. Three dipper dredges of American purchase are not yet ready. Further plant is not deliverable for nine to eighteen months.

The increase in output for the year 1907 therefore must be represented by the getting into operation of the three small dipper dredges, one hopper dredge, the steam shovels not demanded by railroad exigencies and a couple of French bucket machines that may still be patched up. The heralded leap from the meager past of 1906, to the bursting future of 1907, when dirt is to be flying all along the line, lies in the employment of small dredges and some more steam shovels with improved transport and efficiency.

Somewhere along in the spring of 1908, the other little dredges ordered will be getting into service, and the pace can quicken, but the Canal cannot be brought by these machines within far hailing distance of the annual rate demanded for an eight-year completion, since not excavation, but lock and dam building determines the time.

The delivery of plant for beginning a real spurt is not even ordered, so the delay of execution is bound to count much time additional at least. Each month's delay means large further additions to the deficit for obvious reasons.

How much delay in completion is really probable? The rate of output obtaining in the past is not, of course, an adequate gauge or a fit standard for coming things. Far be it from us to augur less of good at Panama than figures at all permit us to hope. The past is instructive only for preventing sanguineness from tripping up the heels of our judgment, and credulity from drugging wisdom. In four years about one-ninth of the mass to be handled for our waterway has

been achieved. This excavation has been in the easier surface deposits. Nearly 45% of the appropriation has been consumed. The French expended 256 million dollars and completed two-fifths of their small Canal in nearly ten years. We, achieving 11% in four years, are to complete 89% in turn-over of our large Canal and build all the stupendous dams and masonry besides in eight years more.

Unless the two Lake areas, Gatun and Sosa, are to hold back all use of the Canal for at least two years, making the years at their minimum ten, their digging above the planes of 40 and of 10 ft. respectively must be done in the dry. The total amount to be handled in the dry under the 85-ft. plan was some 124,615,000 cu. yds. of excavation and embankment. In 1905 and 1906, 2,742,000 cu. yds. were handled, all to nearby dumps. One million five hundred thousand cubic yards of this was in 1906, and it was wasted, at hand. It is still wasted at the nearby dumps and the difficult deepening is untouched. The Sea Level had about twice the volume of excavation of this high-level plan. For it the same method of execution in the dry was provided and adopted.

The "sea-level" was pledged for twelve years hence! These actualities are cited and these facts set forth as illustrative, not at prophetic. They are noted only because the colossal import of such amounts of excavation and embankment are not at all comprehended by the multitude. It is recognized that the yearly output will be increased. It is, however, one thing to set up a pace on easy work and another thing to maintain it on the hard part remaining. There have been canals built before; some of these were in the temperate zone, where steam shovels attain several times the output obtaining now at the rainy Isthmus. In the cooler clime, men, too, are at a higher degree of efficiency, and proximity to supplies and facilities for transport make rates of execution more rapid. Their records of output must, therefore, from all these causes be taken as a favorable standard of human Canal building. On the Drainage Canal of Chicago the average yearly output is given as 5,000,000 cu. yds. with a force of about 7,000 men. The Isthmian rate for 1907 with a force four to five times as great, may approximate 10 million cu. yds. and such an annual achievement would complete the excavation and embankment in eleven more years. But the deepening of the Culebra and the many million cu. yds. of rock under water to be blasted and dredged and the 45 million cu. yds. to be dug, sorted, transported and lifted into

the great dams and railroad embankments portend another and a longer story.

There is a very general disposition to glorify the present at the expense of the prostrate French. Inefficiency and bad management have been so lavishly and so gratuitously attributed to them, that their actual accomplishments have come to be obscured. The French at Panama, like the Cuirassiers of the Guard in the sunken road at Waterloo, are the fallen soldiers over whom our American army is supposed to be charging to triumph. Let us move softly. The French are not of the battle. Their living and dead have filled the pit over which we should be crossing to victory and we need no "woe to the vanquished!" on our lips.

It is incredible that in the rivalry of laudation for everything and everybody American, such distortion of history and such obliquity to truth should be permitted to prevail. One of the leading New York journals, ordinarily very accurate, says: "The present conditions at Panama are the very reverse to what they were under the French regime. Then the conditions were unspeakable and a reign of terror existed. All that has been changed."

"A reign of terror," measured in the greatest rate of achievement in Canal building ever attained anywhere in the world! Have we no saving sense, that we set ourselves up where all informed men must smile? The French, the much contemned French with their ridiculed machinery, in Canal excavation, these have overtopped them all.

It is, however, folly to adopt either an 85-ft. design with its stupendous dams and lock-flights, or a sea-level design with its enormous excavation, in face of the French experience, and our own sterile years. They have disclosed indisputably, at the tropical Isthmus, the costs of certain ways and means, and have marked them as things for avoidance. Their retention foredooms the Canal to stupendous deficits, all unnecessary, and postpones to years beyond the time set by the visionaries responsible for them, the date of the Canal's inaugural. If extended time meant only postponement in utilizing the waterway, it would have still serious moment. But delay adds materially and disproportionately to costs and may add seriously to national perils.

One begins to get an insight into the amount of deficits additional likely to accrue through "lengthened term of construction." Has this accretion been pointed out by the Secretary of War, or the Chairman, or the other guardians of the American people?

CHAPTER V.

FINANCES—INTEREST ON EXCESS COSTS.

In the study demonstrating that there were in straight view very large deficits to cover the construction of the 85-ft. lock project, with all that its design involves, no account was taken of a further item—i. e., the load placed upon the coming generation for interest on the bonds which must be voted by some Congress to pay the excess cost of execution. There must be beyond this, further deficits (and interest thereon) when it is finished, if the capital invested is allowed to run to the great sum for which everything is apparently bound.

In such a world work as the Panama it is the duty of the engineer to point out the best waterway. In this instance it is taken as primary and fundamental that the American people wish and are willing to pay for the best Canal. But the costliest Canal is not at all necessarily the best Canal. This costliest of the lock Canals is a thing of monstrosities and unguardable perils. With the insatiate demand of the 85-ft. scheme right ahead, it is essential to consider the standards of allowable expenditure. These standards are two—the amount fixed by the United States Congress and that calculable as the Canal's value when measured by its practical business utility.

After having thoroughly debated the matter in all its bearings, the legislative branch of the American Government formally dedicated to a Canal at Panama a certain sum. Their judgment as to the business utility of the waterway was recorded in the amount voted for its accomplishment, since by the terms of the law the President was directed to seek another location in event the French vendors exacted too high a price. The amount, therefore, which the Congress of the United States held as a justifiable expenditure is of great significance. Until their action is canceled by subsequent legislation, the amount is fixed and is not to be exceeded.

The authorized cost of an Isthmian Canal may be tabulated as follows:

Authorized Cost.	
For New Panama Canal Co. purchase.....	$40,000,000
For Zone Strip purchase.....	10,000,000
For Annuity to Panama, beginning 1912.....	250,000
For Construction	145,000,000

Appropriation for Construction.

Spooner Act 2% bonds.....$130,000,000
Cash Appropriations out of Treasury..... 15,000,000

Canal as a Business Investment.—The above, then the legislative statement—offers one very important criterion of allowable expense. A second lies in the Canal's economic value as measured by its practical utility. The natural limit of permissible expenditure is the use the Canal will serve to society as against the sacrifice entailed for constructing it. The closest gauge for defining this is the ratio which will exist between the cost of completing the Canal and its future returns.

Since the Panama is to be used as a highway for the shipping of the world and a net tonnage toll is to be collected for each passage, it follows that the waterway may be rationally analyzed in its business aspect. A forecast can be made as to its probable returns, as an enterprise, with the Federal Government as an investor. So regarded, there are three fundamentals to be considered: Earnings, Operating Cost, Capital Investment.

Earnings.—The earnings may be best calculated from the history of other canals. The figures reached by the Commission of 1901 furnish a just working basis. Their estimate of tonnage for 1914 was 6,843,805 tons. With the decade increment which they derived of 25.1%, the available tonnage in 1917 will amount to 7,279,000 net tons. The tonnage for 1915-16, which represents the beginning of operation, will naturally be less. The actual increase in traffic resulting from the opening of the Canal is taken to begin in 1917. The 1893-1903 Suez decade shows an average increment of 45%, beginning with 7,645,000 tons, and this figure is used for the 1917-1927 decade of the Panama Canal.

The Suez and Panama Canals will also be competitors for a large amount of tonnage, and this condition may reduce the above rate of tonnage increase.

Operating Expense.—The operating expense is estimated by the Commission at $2,000,000 per annum. In this item is included the $250,000 a year due to the Republic of Panama after 1912. So that the Canal as a business investment may be reduced to a definite conception.

The first cost of Canal construction, the French purchase, the purchase of the Zone strip, and preliminary outlays were to be:

Capital Required.

Total cost	$197,000,000
Interest ten years' construction period, 2%, ten years, $50,000,000	10,000,000
2%, 5 years, $147,000,000	14,700,000
Deficit until earnings meet operation and interest.	12,000,000
Total	$233,700,000

The time until total expenses will equal income at 45% increase in ten years, beginning 1917, is two and a half years from 1918 or five and a half years after opening of Canal. It should then be on a self-supporting basis, provided the cost is that authorized by law.

The most usual and obvious factors have been used in making this analysis. The revenue from tonnage toll at $1.00 per net ton is the only source of income considered, and this is a fair position to take. Since the fixed charges and operating expenses will remain constant for the scope of these calculations, regardless of the tonnage passing through the Canal, any increase or decrease in the toll per net ton affects in direct proportion the amount of annual earnings and therefore the amount of the surplus or deficit, and finally the amount of capital that can be advisedly expended on the undertaking. For many reasons such an increase is not desirable. The prodigality of the past Canal management has been shown and besides, great cost is inherent in the physical dispositions of the 85-ft. project. Instead of the capital investment authorized by Congress—reaching roundly $234,000,000, for purchases, construction, interest during construction, and the amount to carry the enterprise until self-supporting—instead of this we are confronted with very much over double the colossal outlay.

We have found that $100,000,000 is but a fraction of the waste to come unless there is a plan and method reform. We have seen the deficit creeping up to over 200 millions, aside from interest, and the interest on this sum for thirty-year bonds is 120 millions, or a total of $320,000,000 in excess.

Ponder what it means, if instead of an issue of $130,000,000 of Panama Canal bonds at 2% for thirty years, say even only $100,000,000 more must be put forth. The interest on this for thirty years is $60,000,000, and the bonds must mature some day, and be paid; then there are the deficits from the inability of the income to meet such vast interest besides the

cost of canal operation. Hence the interest begins compounding. With 200 millions of excess cost the case becomes vastly worse.

Deficits are the manufacture of mistaken engineering and management. The thing to be done and the manner of doing it, tell.

To the deficit count must be added the financial consequences involved in delay beyond eight years, together with such important items as the under estimates of dredging indurated clay, in the section from Mindi to Gatun, the added cost of constructing the Gatun Dam by necessarily substituting dry for wet methods, the lengthening of the six locks to 1,000 ft. each, and their widening to 110 feet or more in response to the demands of battleships, the incorporation of imperative reception basins below the first locks at either terminus; the equipping of the Canal and harbors, etc. All these bring the total to over three hundred and fifty million dollars above that authorized for the Panama Canal.

Three hundred and fifty millions of possible waste in carrying out the 85-ft. lock-flight project—and it was all unnecessary.

What does a possible three hundred and fifty millions of excess cost or loss represent?

At every session of Congress legislators are in struggle, each seeking for his own district the sorely needed appropriations for waterways. There are scores of cities and districts shackled and bound because the money cannot be had to make sufficient and efficient their water dependencies. The division of even a fraction of this at home would lift the incubus from many a straining community. The entrance channels to New York and Philadelphia Harbors, affecting every ship doing business there, could be dredged and established permanently to 40 ft. for, say, $10,000,000; the Cape Cod Canal could be cut, $5,000,000; Portland, Oregon, could be made safely available to the largest vessels afloat, $6,000,000; Charleston Bar, better jettied, could be permanently removed, $7,000,000; the Mississippi Levees and port protections could be reinforced and the Deep Waterway from Chicago to St. Louis be established, $41,000,000; San Diego Harbor could be dredged, $6,000,000; Chicago Harbor could be protected from northers by a stone breakwater, $7,000,000; the Sacramento could be leveed and dredged, $5,000,000; Galveston Causeway to the mainland constructed, $1,000,000; all this is but $88,000,000, and there is still $262,000,000 left for other improvements at home.

To-day in the midst of our boasted opulence there is yet not such plethora but that the Pennsylvania delegation begs for a chance to develop the Delaware. Buffalo is petitioning, as is likewise Galveston and scores of other cities. These large sums are unrealizable.

National stringency in any form strikes first at internal improvements. Is there a war, or a falling off in revenues, all items of home development are sliced in the appropriations and our own communities go straightway under curtailment. Three hundred and fifty millions cannot be wasted on Panama without a very marked retrenchment in affairs at home.

If at Panama 300 millions can be saved, let us not boast our teeming treasury and fritter them away. Were all our purposed water channels secured there would be little red school houses a-plenty in need yet in our land. There are hospitals wanted still there at the bottom for those whom our ruthless competition has broken in body, and humaner prisons for the outcasts whom it has broken in soul. "Mistakes," "technical misadventures"—the sophistry of covered disaster and ruthless waste!

Let the public trust be lifted above such things. Let us be glad of our prosperity. Let us stand and dispense our national fund with wise generosity not in the folly of the niggard! Let us lift our heads high to the heavens and keep our eyes straight to the full-orbed day, but dollar for dollar let America build her Canal!

CHAPTER VI.

PERSONNEL.

In view of the nature of the Isthmian proposition and its absolute dependence upon right technique, it is in order to examine the engineering judgment in which this eighty-five-foot project at Panama has been established and is fixedly maintained as a closed case. The personal phase is touched upon with regret. The members of both Minority and Commission were affable gentlemen, and social amenities would insure silence. But the Panama Canal, holding the Nation's honor in peace and service in war, is at stake in their engineering, and personal considerations on both sides must give place. Public officials in their public capacities are legitimately weighed and measured. Their technical past belongs by all ethics to history, and the people have an incontestible claim to the official record. This only is reviewed.

There have been in recent years of American Engineering several notable misadventures—the collapse of the Ashtabula Bridge, the breaking of the Johnstown embankment, the failure of the Austin Dam, the irruption of the Colorado River into the Salton Sink (and recently the fall of the Quebec bridge). The greatest of all menaces and the most crucial of professional commitments centered in the Bohio Dam at Panama. The story of it must be prefaced with a little back history.

The selection of an Isthmian route for the Canal had been long and hotly contested. It began three hundred years ago, but it was in the memorable Paris Congress of 1879 that the first great clinching of parties came. Our own American engineers were there—Rear Admiral Ammen, Lieutenant Commander Gorringe, Mr. Menocal and others, and Commander Selfridge, invited by M. de Lesseps personally. The Americans were almost all Nicaraguan advocates, and they pressed its advantages with ability. So moved were they at the high-handedness with which its claims seemed to be put down and Panama's put up that they detailed much of the under history of the Congress in their report to the United States Government. It is a valuable, scholarly presentation, but to get a full understanding it must be read in connection with the French official report. Then it becomes one of the most amusing records in technical literature.

The Rear Admiral headed the accredited delegation—Ammen

dignified, careful, solemn and weighty of every professional utterance; an officer impressed with the great import, technical and financial, of an Interoceanic Canal. He was unfortunately not over agile with "the gift of tongues." Undelegated came Commander Selfridge, debonair, lithe of mind and glib of French. Selfridge was Nicaragua's most deadly foil. He was in perpetual rise "for the Atrato-Napipi." Was there any marked merit at Nicaragua, he went it one better on the Atrato-Napipi. Was there any badness in any project—it was outdone by the alarming condition of the harbor at Graytown and the earthquakes at Nicaragua. So the Rear Admiral felt it incumbent to let it be known that HE was head of the American delegation, and they were for Nicaragua, and not for the ubiquitous Atrato-Napipi. But the assembly was hopelessly mixed, and the members seem to have become only more mixed as to the American contingent.

But our delegates were not to be swept away from the first principles of engineering because of the unpopularity. In the final session, with its culmination of hero worship, with its cheering men and its delirious women waving approval of each accession to the Panama vote they sat immovable, and in the last exciting roll call they declined to vote. "Only able engineers can form an opinion after careful study of what is actually possible and what is relatively economical in the construction of a ship canal." "Imaginary projects traced on imperfect maps of the Isthmus, some of them the result of one night's inspiration," such engineering could not set on the consciences of these American engineers, so the Panama officials dubbed them "egotistical enigmas."

But the Panama route was in the hands of M. de Lesseps and "a man of many wiles was great Ulysses." A couple of Frenchmen had bought out the concession obtained from Colombia by M. Gorgoza. It had seemed of sufficient value to General Turr and Lieutenant Wyse of the French Navy to warrant some preliminary surveys. These officers interested M. de Lesseps, who had just carried Suez to completion.

The report of the American delegates to the Congress, written in 1879, gives two notes which are of interest. It summarizes the technical review thus:

"By these proceedings the remarkable condition is presented of engineers designing and estimating on the cost of such important work as the one under consideration without a proper knowledge of the ground on which the works were

to be constructed, which was generally regarded as well as that of cost, to be a matter for after consideration. It is expected that the impracticable scheme proposed for Panama (the Sea Level) will soon be abandoned for want of supporters."

Here, then at the very beginning of the Panama Canal designing, we find an evil genius laying upon it that malign spell, which nothing seems to lift, the blight of the paper location.

Chagres Dam Launched.—A second feature on which the report comments runs thus: "On the 26th of May (1879) the technical sub-committee met to discuss a new plan, based upon making a huge dam at some point across the Chagres River, with the intention of forming a large lake. Ten days before, this dam had not entered the mind of man."

Thus airily, without a shred of information as to the formation, without even a pretense of data, the first great Chagres dam was launched.

The failure of the French company brought us in 1901 an opportunity for a free choice of Isthmian routes, and the question became whether it were best to purchase the French investment and build along their route or to hold to our distinctive field and build at Nicaragua. Congress appointed a Commission to study the situation and report fully and exactly with recommendations. One million dollars were put at their disposal for an investigation. Upon this Board sat three of the engineers recommending to-day the eighty-five foot government project. More than a year was consumed in the examination of the Panama property, its sites, its structures, its hydrology, etc. The million was expended so exactly that not enough was held to publish the report, which was issued in abbreviated form. Three years later a full history was published from other moneys.

Brother of the Gatun Dam.— An eighty-five foot, six-lock canal was advised, whose central feature was the massive masonry-core, Bohio Dam. This dam was the heart, the crux of the whole waterway. It was, like its brother of to-day, a stupendous mass, and it, too, held a Central Lake, eighty-five feet deep, and some thirty-eight miles in area. The cumulation of the Nicaragua opposition had come through the years to center chiefly against the Panama Dam. Their engineers had maintained that, under Isthmian conditions, this huge structure was unsafe and to be deprecated.

But the Commission of 1901 gave to the Nicaragua project instead the coup-de-grace, and they did it by maintaining that the Bohio Dam, as planned, with a Masonry Core, was a safe and a certain engineering proposition. Each member of the recommending commission was examined minutely by the Senate Committee regarding this long-condemned central feature, but every man was ready; the Bohio Dam had no wavering defenders.

Senator Hanna—With reference to this Bohio Dam have you any doubt about the practicability of the construction and operation of that dam?

Mr. Noble—No, sir; I have not.

Senator Hanna—None at all?

Mr. Noble—No, sir; none at all.

They all stood together before the Senate guns in the same cross fire, and the declared safety of the Bohio Dam sealed forever the fate of the Nicaragua enterprise.

Believing the engineering to be competent and trustworthy, and supposing that the technical judgment of these men was a full and valid warrant for action, Congress purchased the French investment for 40 millions and authorized an appropriation of 145 millions for the construction of the Panama Canal. Office and field forces were sent down to begin work. As one of the first proceedings supplementary borings were instituted on the site of the proposed huge dam to corroborate the 1901 Commission's testimony. Then came the revelations. The rock which had been announced and directly attested before the Senate as safe and certain for foundations was found non-existent; nor could right foundations be reached within any distance which made the building of the colossal structure practicable.

The Great Bohio Dam Project Fell in a Night.—The very core of the eighty-five-foot six-locked waterway, on which both the purchase and the appropriation for the Panama Canal had been based, was virtually swept to perdition by the revelations of the first competent borings. The truth was unescapable—the examinations and explorations had been made incompetently, under inadequate or faulty engineering, and the verdict and recommendation in the very pivotal element of the waterway had been disastrously wrong. The idea had to be abandoned and more money expended anew, to hunt and explore another location for the crucial dam. The Senate reminiscence reads as follows:

Senator Kittredge (page 1845)—The reason I ask this

question, Mr. Noble, is this: You remember appearing before this committee four or five years ago?

Mr. Noble—Yes, sir.

Senator Kittredge—And recommending strongly the Bohio Dam? On that occasion you told this committee that there was no doubt whatever about ability to go to bed rock and lay the foundation of the Bohio Dam. That was right, was it not?

Mr. Noble—Yes, on the basis of the borings we had then, we were very certain.

Senator Kittredge—I understand. Now, then, when more careful examinations and borings were made, the fact was disclosed that instead of striking bed rock at 120 feet below sea level, you had only struck bowlders or at least had not struck the deepest point at that place. That is right, is it not?

Mr. Noble—I think the latter is the case, Senator.

Senator Kittredge—And when more careful borings were made, the lowest point at the Bohio Dam site was 168 feet below sea level. That is right, is it not?

Mr. Noble—I think that is correct, yes.

Senator Kittredge—Suppose that the lock plan is adopted by Congress, and then you make further and more careful investigations and the fact is developed that you cannot build there (at Gatun), what then?

Mr. Noble—I do not think you can apprehend any such result as that, Senator.

Senator Kittredge—That is precisely the result that happened at Bohio, is it not?

Mr. Noble—It certainly is. The project of sinking caissons to full depth at Bohio is, I think, impracticable.

Senator Kittredge—And you advised that that be done at Bohio?

Mr. Noble—Yes, that is true.

Senator Kittredge—When you were before us four years ago?

Mr. Noble—Yes.

Discredited Experts.—In any private enterprise these experts would have been quite finished, as authorities; they would have been relegated to harmless duties. In no other country in the world save America, after such a vital and radical blunder and miscarriage in a national project, could they have been called again to public posts, where value was measured in technical judgment, care and responsibility. But when another Commission was named to undo the mischief of this one, and select anew elements and sites for the helpless waterway, we find right in the forefront of power two of the experts of the discredited Bohio Dam. They were put on to have another toss for the heart of the World's Canal. And when later the Inter-

national Board was called, we find a third designing and recommending the most momentous feature of the whole gigantic undertaking—the flights of locks.

The army, whose reward of highest attainment is the Engineer Corps, is not so destitute of minds that it need be represented the second time by the men who had proved unequal to their first task.

This national waterway is a public enterprise, and every man connected with it should be weighed in the scales. The premise was that the Panama Canalwas primarily an engineering matter, that the right, technical judgment was the fulcrum, with the whole execution swaying at the other end of the lever; that the value of an expert lay in two elements—the power of rightly diagnosing and the power of rightly prescribing; that as he possessed or did not possess these qualifications he was a success or a failure, the right mind or the wrong mind for the enterprise; and that the loyalty of its friends could be measured in nothing so surely as in their fearless and open elimination of the wrong minds from the destinies of the waterway.

Had the authorities no responsibility for the sequel; the sequel befitting the quality of engineering honored on the Canal? What could the harvest be but Dead Sea fruit?

The records of the remaining engineering sponsors for the eighty-five-foot Panama Canal are happily not set against such a dark background as the Bohio Dam. But the turnings and vaultings in canal designing and recommendations mark an extraordinary trail.

That Isthmian Canal Commission had two members—the chairman and Zone Governor—who are self-confessedly not engineers at all, civil or any other kind, not naval constructors nor navigators, nor seamen. One is a railroad organizer, the other a very competent and successful Governor. Being wholly without training or experience, they are quite unqualified for considering hydraulic questions or plans. It is a sacrifice of all chance for rational solution to have a great world problem like the Panama Canal design decided by the opinion and vote of men, however competent in other fields, thus fundamentally unfit.

A third Commissioner foreswearing his colleague's engineering goes to the sea-level. A fourth stands now with the high level, reversing himself, for he moved to adopt the sea-level scheme in the last Walker Commission. The fifth

and sixth served on the Commission of 1901, whose plans incorporating the Bohio structure were made the basis of the canal purchase, and the authorization of the Spooner Act.

Likewise these two men, together with their colleague of the minority, had condemned as unsafe at the Isthmus any dam which had not a masonry core founded on rock. Now, four years later, they vote to build an even huger dam of earth, on a spot which they themselves previously rejected, and they base it upon openly acknowledged alluvium. As they gave learned opinions of the safety of the Bohio Dam, so now they heap up assurances as to the safety of their high Gatun Dam. This was the personnel of the Isthmian Commission that accepted and recommended the eighty-five-foot project.

Next as to the engineers constituting the minority of the International Board, the fabricators of this high-level, multi-locked canal. The first was the condoned expert of 1901, the engineer who had no doubt as to Bohio. "No, sir, none at all." He designed, drew and estimated the present lock flights, the most momentous and deplored feature of the whole waterway, and he located them, as will be seen on "four borings, or rather three" for data. The second engineer had sat upon a previous Isthmian Commission and had publicly and ardently advocated, as the only right solution for Panama, a project quite different from the one now supported by him. He had within three months published a book setting forth by the strongest arguments and through his deductions from French data of Chagres discharge his conviction that the high-level type was unsafe, the sea-level type anathema, and the four-lock 61.5 foot the only correct solution. In the face of many years' denouncement and condemnation of an 85-foot summit level, he now votes for it, but his long testimony as to its perils compels him to dissent from the location of three locks in flight at Gatun. He begs the compromise of setting one of the locks at Bohio.

A third member of the minority voted four gigantic unexampled earth dams, each despite the great difference in conditions, modeled on his one relatively simple chef-d'œuvre. What data he possessed will be set forth in the coming article on the Gatun Dam. A later chapter will describe the failure of this chef-d'œuvre on April 11, 1907, when one-seventh of the crucial mass of the Wachusett Dam went down into the reservoir.

A fourth followed his leader matching the dams, in massive, stupendous and quite unprecedented flights of locks, with the same "four or rather three borings for data." Both recommendations were brought by their size into the field of experiment. These massive concretes were more than a mile long.

The fifth step-fathering here a high-level design, is on public record in support of a sea-level tunnel scheme through the mountain of Darien, as the solution for the transisthmian canal. He "most unhesitatingly recognized the practicability," etc., and he "believes that I can organize a body of the ablest contractors to be found in the United States who will do the work for these prices." He is opposed to locks, and observes that he "need not take up the manifest advantage of an interoceanic canal without locks, because the obvious need not be dwelt upon." He abandons now the sea level, tunneled, lockless Darien-Mandingo of 1902, and advises a very high level, six-lock canal, not at Darien, but at Panama.

Of the nine men, therefore, of the combined bodies, who, being engineers, might supposedly speak with some authority upon this technical matter, one has gone to the sea-level; six have quite changed their previous public and studied published recommendations, while the two new men voted their own specialties in colossal and quite experimental features with an open gamble on foundations.

What can be said of the two bodies posed as experts of the first order, whose opinions and advices in a matter involving in only the purchase and estimate around 250 million dollars betray such radical changing, inconsistency and defiance of the first principles of precaution? Can such decisions, convince any one, or pretense long mask the fact that they were and are at sea as to what to advise for the Panama Canal, and have engineered loose-handedly in confusion, and compromise? Not one of the various Commissions or Boards, or Chief Engineers responsible for the 85-ft. scheme or the sea-level chimera has in November, 1907, any place or part in the canal enterprise.

When the child is stricken and the doctors diagnosing one thing and another thing and again another thing, dose him to ever-failing strength, it is not amiability then, or influence then, or friendship then. It is one thing and one thing only, and we call aloud, "Give us skill, give us knowledge, these alone can save!" We left the crucial cutting of

this precious canal body to surgeons not only ignorant of its antomy, but indifferent to its anatomy, to men who fettered its limbs in massive locks, without even inquiring if its limbs could carry them—men who loaded the crushing mountain upon its back, without even seeking if its back could carry the mountain.

The climax of "engineering by autocracy" came in the locating of the massive masonry lock-ladder at Gatun. Here was the full fruition of Bohio, the inevitable sequel to its methods. The flight of three locks had been by the majority of the International Board uncompromisingly denounced as "the most dangerous feature that has been proposed for any canal." It had been declared "so perilously near impracticability (for navigation) that no scheme involving it should be accepted." This lock fight was the creation of the former Bohio Sponsor. He testified before the Senate Committee:

"I made the plans of the locks myself, Senator; I made the estimates of them. I sketched out the plans of the lock personally, and I personally made the calculations of the quantities."

It was supported by the second new board member—a specialist likewise. These two were responsible at first hand for the flights, as the dam specialist was responsible at first hand for the Gatun Monster. The other members accepted and recommended the features, as did also the Commission (all but one), the Chief Engineer and the Secretary of War.

The first and indispensable requisite for formulating a plan of any kind is data; the greater and more vital the feature, the more comprehensive and detailed must be the data. For an unexampled flight of massive concrete locks and approaches, the need of the right foundations is so glaringly self-evident that complete and exhaustive information was imperative before any valid engineering opinion, even upon the possibility of locating there a flight of locks at all, could be entertained. Manifestly its weight could be ventured only upon adequate and unassailable sub-strata continuous every foot of the way.

Remembering the absence of knowledge in which the French had projected their sea level and had been forced later ignominiously to abandon it, and recalling our own inauspicious beginning in the Bohio foundations, the President had been solicitous and he gave exact and comprehensive commands. He wrote:

"The Isthmian Canal Commission is directed to have all

the proposed plans in such detailed form with maps, surveys and other documents sufficient to enable the consulting engineers to consider and decide the questions presented to them."

The author of one Panama design long before requested the Secretary twice to order certain borings. But why should the President be anxious? Why should he trouble about data? What did data matter? There was no time, and the engineers were not exacting much. They could design whether or not; there was no inconvenient Rear Admiral Ammen among them. The spell, the same old blight, was spoken over it for the third time—the blight of the paper location. The Paris and Bohio circuit was complete.

The board convened on September 1, 1905. On their adjournment this 85-foot design with its stupendous masonry lock flight was adopted by the minority, was supported by the Secretary of War, was announced to the country as safely and certainly accredited, was advised to the President, and was recommended to Congress.

In March the Senate Isthmian Committee that had received and credited the Bohio story, began investigating this second design submitted for the Panama Canal. They found it strangely akin to the first. The same 85-foot level was taken, necessitating again a deep Central Lake and the old stupendous dam. This time it was huger than before. It had abandoned Bohio now, but had only moved down stream ten miles and had established itself at Gatun instead. The locks were more formidable than formerly, they had been huddled into a tier of three and were projected into and overhung the rock of the Gatun Hill. The whole design looked so like a grown-up presentment of the old familiar face that they instinctively began investigation as to foundations. What was the engineering on the canal this time? What were the evidences of caution, of care, of safeguarding, of knowledge, of skill?

The masonry lock flight being of stupendous weight and great extent and holding the passing destiny of every ship that should cross the canal was naturally the greatest concern. The chairman questioned the designer of the lock tier —the same engineer whose Bohio Dam plan had gone to the limbo of the impossible (Senate Testimony, page 1,884).

Senator Kittredge—To what extent had your board and have you in your possession information concerning the char-

acter of the Gatun Hills in the vicinity of the proposed locks?

Mr. Noble—There are some borings in there, but I do not think they extend the full length of the lock. There was no time to get all that information.

Senator Kittredge—Do you not think it was desirable to have that information?

Mr. Noble—Oh, extremely.

Page 1793:

Senator Kittredge—How many borings were made in the Gatun Hill in the vicinity of where the locks are to be placed?

Mr. Parsons—There were nine borings made, I think, Senator, on a different location. This map shows them. There were seventeen borings made altogether, and it was figured at that time that the locks should take that direction, as you can see by those black lines. (Indicating on the map.)

Senator Morgan—The seventeen borings were on the lock site?

Mr. Parsons—On that lock site. Not on the lock site that was finally adopted. The seventeen borings were made on the first lock site as proposed by the committee. Then they found that the hill in that section was too short to accommodate the locks and the location was therefore changed * * * so that these borings down here give no information at all as to the condition of the lock further to the east. Therefore, as a matter of fact, there are four borings or really three that come within the lines of the lock as shown by the minority report.

Senator Hopkins—How far out are they, Mr. Parsons?

Mr. Parsons—That distance is 500 feet. You can see that all these borings down to the west of the canal on the lower part are from 500 to 1,000 feet away.

Senator Hopkins—From the actual location of the locks?

Mr. Parsons—From the actual location of the locks. And if you will refer to the plates showing those borings there given in the report, you will see the indurated clay, for instance, which is the material on which they expect to found the locks, and how it will vary in position between two borings. You see it is liable to fluctuate very widely.

Senator Knox—It is liable to fluctuate widely within what distance?

Mr. Parsons—Oh, in a distance of two or three hundred feet it would fluctuate widely. * * * You can see how close the borings were made there (indicating) and on the site of the locks no borings were made at all.

Page 1981:

Mr. Wallace—In my own examination of these borings—there have only been four or five borings taken throughout the entire site on which it is proposed to build those locks, which, with their approaches and wing walls, extend upward of a mile in length, and my criticism of the lock plan was this. * * * And it would seem the part of prudence

before a lock plan of that magnitude and importance is undertaken that the most thorough borings should be made over that entire area and at least as close together as 100 to 200 feet apart, both laterally and longitudinally.

Senator Dryden—These borings have not yet been made, then?

Mr. Wallace—I understand that they have not.

Senator Kittredge's speech, page 1732, reads:

"They (the minority) propose to construct locks having a usable dimension of 900 feet in length and 95 feet in width, three in flight and the lock structure, the guard walls, approach walls and all the other necessary elements of that design will make a structure more than one mile long. It will be observed, if one examines the map, that with one or two exceptions, not a boring has been made under the site of the proposed locks at Gatun to determine the foundation."

On superficial knowledge of four holes, therefore, the monster experiment of all time was formulated by the minority, supported by the Commission and the Secretary of War, with all the enginery of the government back of them, and announced to the public as safely founded and unassailably entrenched. Then the Commission set about getting data, to ascertain whether or not the lock flight could even be built. So reckless and unprofessional a system of engineering and of directing a public enterprise could not be found in all American annals.

These revelations as to borings brought some consternation to the Senate Committee. Other facts came to light, grave facts, which will be reached duly. The easy complacency of the Secretary and the Chairman were shaken for a moment. The former wired the Chief Engineer:—

March 18, 1906.

Would it not be wise for you to examine and measure Gatun Hill with reference to the questions raised by Burr and Parsons? It ought to be done, if done at all, at once.

Taft.

Now certain facts are circumstantially revealed. The 85-foot experting, engineering and supporting were being unmasked. All the government forces had rallied to the defense. Were the data in possession of the Commission established at Washington, they could have been produced on the spot. There would have been no need to wire to the Chief Engineer of the sorely disturbing condition, and bid him "measure at once." The Commission could produce only the maps of the four borings. Further, the Chairman

himself, in addition to the Secretary of War, began wiring for the data. The Senate testimony gives this:

(Confidential.)

March 16, 1906.

Stevens, Panama:

Burr and Parsons testified in favor sea level and strongly against lock, asserting Gatun Hill not large enough to permit construction three locks in series with usable length exceeding 790 feet each and proper foundation dam not attainable. Noble testified in favor of lock canals, but had no figures to refute statements about length Gatun Hill.

Shonts.

This last named expert was the engineer who testified that he had designed the lock flight in person, drawn it in person and estimated it in person. The Commission had supported and accredited it to the country. There is the Chairman's own confession and the date was March 16; five months later "he had no figures about the length of the Gatun Hill."

The reply was dated March 20, 1906: "Have fully developed by one hundred borings 3,800 feet in length and 300 feet wide on exact site of three locks perfect foundations, etc.

"Stevens."

From the adjournment of the Board, therefore, in November until March 20, the confiding public was happy in the belief that the Gatun lock foundations were reposing unchallengably upon the rock. Meanwhile the chief engineer was engaged in making the belated borings upon which their very existence depended. He relievedly proclaims the saving of the situation and the mercy of Mother Nature to this closely pressed lock-tier. The "ideality" of the Gatun Hill conditions come into the lock analysis; here the data story alone is being considered.

By March 20, then, the Commission, alive to the probings of the coming Senate Committee had marshaled together at the Isthmus, but had not yet got to Washington, one hundred borings under the locks. The testimony of the majority had been that these borings should be very numerous and very close together under a great masonry structure more than a mile long. But the 85-foot project had run through the Senate gantlet and the general lock type was ordered. The Commission settled back to its laisser faire. There were no more Senate probings in sight and the people had accepted the vouching.

The Investigating Committee had brought out other equally compromising testimony. The section between Mindi and Gatun was under discussion. The revelation here ran (page 1627):

"The majority excavates along the old canal line, digging down to 40 feet below sea level. The minority cuts a new line through a series of hillocks made of hard clay.

The fact has developed that except at the intersection at the mouth of the Mindi the minority had in hand from there to Gatun, a distance of nearly four miles, not a single boring on which to base the estimate to which all their responsibilities are attached. There existed neither a profile of the surface nor one of the indurated clay. Their new line was away to the eastward of all the canal excavations of the French company, and therefore away from all accurate knowledge of actual strata. It is not to be credited that the minority has figured in enough refractory excavation. It is concluded from a careful study that, between Mindi and Gatun especially, the quantities allowed by the minority are far too small. When the line is actually surveyed, if it ever is to be, and bored, it will undoubtedly be found that they will have over double as many cubic yards as they now contemplate of clay refractory from a dredging standpoint."

Through one-tenth of the Canal length, therefore, the minority, the Commission and the Secretary of War located their channel and gave estimates for its cost without one shred of information or one tittle of knowledge. Since the Senate revelations some fifty borings have been made through this four-mile section. The evidence of even these few tests is conclusive that the quantity of indurated clay is double that which they named—a serious increase of cost.

This is set forth by the Commission itself in the "information" sent out to bidders. Engineering and estimating by guess, therefore, is likely to be a luxury indeed for the American treasury.

In December, 1906, came the invitations to contract. The canal technique passed now a different gauntlet. Contractors were not lawyers or senators, but they were engineers, and practical executives. They could gauge and weigh values in professional judgment and could analyze evidences in data which the Senate Committee, with all its good intent, was not technically equipped for estimating. The reception of these invitations was so unequivocal that the Chairman withdrew them, and announced publicly that contractors declined to stand for the government's experting. The features of the 85-foot canal were pronounced "too risky" and

the borings—the borings—were not sufficient for any safe or sound business.

The Senate Committee has realized the ominous meaning of a national waterway built of such features and founded on such evidence that experienced men will peril nothing in it. They called again for borings, the borings of the year. Though still another ten months had gone by, few further tests had been ordered or made except in Spillway Hill, as the annual report of 1906 showed.

With the possible lock lengths and the safety devices, burdened with the very brunt of defense to every ship that shall ever pass at Panama, both dependent upon right formation beyond the 3,800-foot belt probed, the remissness in the matter of data is something incomprehensible.

The authorities at Washington have upheld and defended all this. When the engineer or the waterway must be sacrificed they have sacrificed the waterway. They tell us these are great engineers. They are more than great; they are phenomenal; they are extraordinary. They are great past anything yet recorded, anything yet dared. Professional men heretofore have needed the homely bases—data. They have built upon some foundations. They have gathered the facts and truths of Mother Earth—earth, who will not deceive nor be deceived. But these had been beyond the common needs and the common bonds.

OLD ASPINWALL, NOW COLON.

COLON
Manzanillo Bay
Mindi Pt.
Mindi Land
Mindi Station
Toro Pt.
Toro Land
Toro Station
Gatun Locks
Gatun Dam
Gatun Lake
Gatun Spillway
Gatun Station
Gatun Power Station
Gatun Power Canal
Gatun Power Dam
Gatun Power Station
Gatun Power Canal
Gatun Power Dam
Gatun Power Station
Gatun Power Canal
Gatun Power Dam

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PANAMA CANAL, SHOWING OUTER AND INNER HARBORS, LOCK
AVAL STATION—BY LINDON W. BATES.

CHAPTER VII.

Atlantic Harbor and Terminal City.

There have been many landing places and many routes across the small divide—this fevered Isthmus, this swamp-entrenched, jungle-clad pass across the Cordilleras. Who would have dreamed the day the "Admiral of the Seas of Darkness" cast anchor at Porto Bello, east of Limon Bay, that an Admiral of the far Cipango which he sought would sweep from her coasts the fleets of a white race, four centuries later! Porto Bello, San Lorenzo Castle, Chagrestown, Toro, Peacock Bay, Manzanillo, Aspinwall, Colon, Cristobal, Mindi, they mark the trend of a beautiful, vapored, miasmic, sinister shore.

The paved treasure road of Spain led across the low mountains from Porto Bello to old Panama, the richest town of its size in the world. Porto Bello was a safe harbor for sailing craft which could not hope to escape the "Northers" in Limon Bay and dare not lie off the reef-bound mouth of the Chagres emptying there before the Castle on the black rock.

With the advent of the steamship, Porto Bello was forsaken and the Argonauts of '49, gold-mad for California, landed at the mouth of the dreaded river, paddled to Gorgona over the precious Reef, crossed the Divide afoot or on muleback and sailed away over the Pacific to their land of the Golden Fleece.

There had been many quests at Panama. It was ever the land of secrets—the Secret of the Unknown Ocean, and the Secret of the Strait, which scores of mariners after "the Admiral" had come seeking; the Secret of El Dorado, the Golden-man; the Secret of the Undiscovered Inca Empire; the Secret of the vanished Treasures of the pirate-sacked cities; the Secret of the Lost Pass.

In 1814 Spain, unreconciled to her decline and seeing her early glories merging into memory and tradition, strove to recall them into living force. Her hold upon the American colonies was loosening and her vestige of power was slipping forever away. She decreed the construction of an Isthmian Canal. But her day had gone; the colonies revolted and fell from her impotent grasp.

Bolivar of New Granada gave to the "King of New Zealand" a franchise for a Panama Canal, and later he commissioned a Swedish and a British engineer to survey the route. The line which these two men mapped was wisely projected, and it became afterwards substantially the route adopted for the Panama railroad.

Granada later gave another concession, and Morel made surveys for a route between Porto Bello and Panama. He reported a low dip in the mountains where the crest was but twelve metres high.

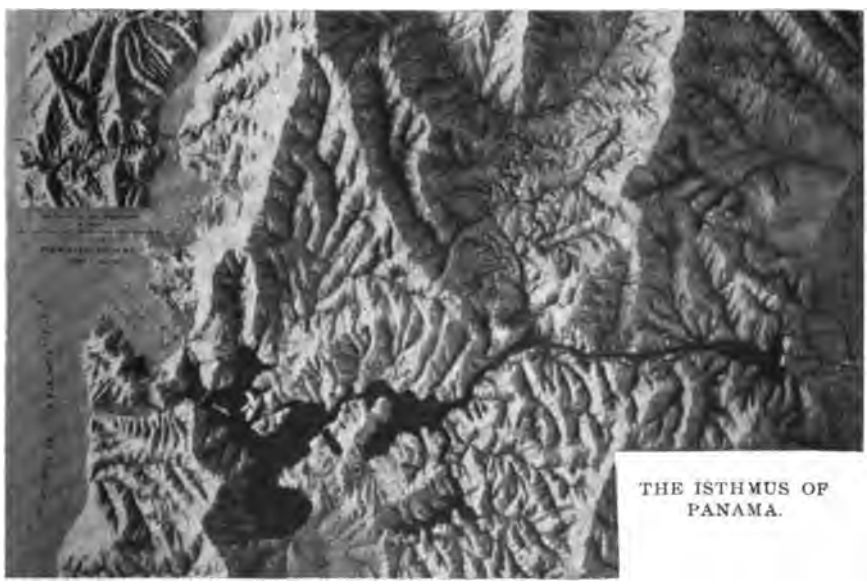
It was to find this, the Lost Pass, that M. Guizot, Minister of France, in response to the importuning of believers in the hazy traditions and tales of the Darien Indians, sent out to Panama, in 1840, Napoleon Garella, an eminent and sensible engineer. The Pass was said to be only about twelve metres, or 40 feet high. Garella was to discover this dip in the mountains and to locate through it an Interoceanic Canal.

He did not find the Lost Pass. Where it was supposed to be, there were several passes, each nearly ten times as high as the one so fervently assured to the Minister and so ardently believed. Of these passes, the one which Garella preferred led from the upper reaches of the Rio Cano, the largest western tributary of the Chagres above Bohio, to the Bay of Caimito, 12 miles west of Panama. The terminal he selected on the Pacific was "Voca de Monte." He got his small lock canal away from the Chagres as soon as he could, and did not essay the route which he well knew around the Culebra Hill and down the Rio Grande to the Bay of Panama. He left the Chagres at the mouth of the Trinidad, above Gatun, and struck around and across the low western hills into the valley of the Benito, a branch of the Cano, thence through the Pass into the valley of the Bernardino and to the Sea. He stood on the hill at Gatun, where so many have stood before and since, and looked seaward across the swamps which he "could not cross." He marked through them on his map a short cut to Limon Bay, around the foot of Jaramillo Hill, to a haven on the West Shore, half way to Toro Point, where he set his proposed terminus.

But Garella's plans and the syndicates' hopes for this early water link were put to sleep when he reported the Pass at its true height. The Divide was too formidable for adventure.

If the French delegate could not cross the morasses, a British hydrographer could—the gifted Peacock. He formally entered Limon Bay in 1834, and with Indian guides walked from the deep bight at its western head to Gatun. He memorialized M. de Lesseps in 1879 and gave a history of his expedition. He made a map showing the terminus for his proposed canal, on Peacock Bay west of Jaramillo Hill.

It is a rara avis of an engineer who knows how to make a conclusive reconnaissance in a tropical thicket.



THE ISTHMUS OF PANAMA.

Then came the Panama railroad and its fevered driving against stupendous odds to completion. The California rush was on, and the golden age for this interoceanic link. The railroad engineers discarded the valley of the Chagres below Gatun, flanked as it was on either side by flood-swept banks and lined by steeps of rugged clay-rock, slimy and slippery with weathering in the drowning rains.

The railroad engineers passed over the western shore of Limon, or Navy Bay, and the safer anchorage near Toro Point, and started their constructions from Manzanillo Island

on the further side, whereon was founded the railroad town of Aspinwall.

The French Empress Eugenie, impressed with the ungenerousness of paying here no tribute to Columbus, sent out the statue which marks the entrance of the French canal. In deference to her memorial, the French changed the name from Aspinwall to Colon.

Chagrestown and Porto Bello have been the nightmares of three and one-half centuries. Colon, the Isthmian Canal and Mount Hope, its dead city, have had the cycle of but fifty years.

The Outlook for September, 1906, had a very laudatory article on the canal work, with approval for nearly everything on the Isthmus. It explains Colon's bad record by its natural handicaps. It writes:

"Briefly the situation is this: Probably no town in the world of its size presents so many difficult problems of sanitation. Swamp-built Colon is a natural hotbed of disease. The filth of years of foul living reeks from its mud. It is peopled almost wholly by ignorant negroes, many of them the rejected and worthless employes of the commission, who in their huddled living disregard every rule of health. The chance that the selected plan for the canal might cut off Colon and allow it to perish from very uselessness has passed. It must still remain the receiving and distributing station for the vast bulk of men and supplies that are pouring into the zone. Thus the health of the whole Isthmus depends upon the health of Colon."

This reviewer thus recognizes the force of the contention that Colon, the focus of Isthmian disease, should be ultimately abandoned, and a new right terminal city be built elsewhere. The Mindi hills, are the natural place for the Atlantic city. Here the heights afford the right environment. If Colon was to be retained, why was not Colon made fundamentally sanitary?

The island's engineering surgeons have been sadly slack. Colon has had nearly two generations of existence, and but 500 acres. Since the year of our canal purchase stricken Galveston has lifted a thousand acres of herself a dozen feet with sweet, clean sea sand. She has kept clear of yellow fever when it was all about her, and has been more healthy during the trying process than ever before. The very first

proposition which the Isthmian Canal Commission had before it, the day it organized, four years ago, was one to raise and redeem Colon. But it did little save dig a currentless trench in midstreet at the level of an all but tideless sea. When, with its millions of money and the guardianship of such a stake in health, it paves a narrow trench or two, or toiling, makes some gutters, the world is called to witness in dozens of illustrated encomiums the worthy achievement Colon is not Galveston, the commissions are not like her grade raising committee. Both had the people's mandate to do the right and the best. But the latter has had the will and the wisdom, and they cherished their city supremely.

There were half a dozen ways to raise the Colon site—

STREET IMPROVEMENT IN COLON.

the easiest by dredgings from the harbor and canal near Cristobal. But the material removed at conspicuous expense has been wasted at sea—the same sea of waste at Panama!

An Atlantic harbor is wanted for our new canal, a harbor commodious, safe for ship and life, easy of access and departure and fully equipped; a refuge, a defense, a warden of our United States supremacy at this gate of nations. Limon bay affords scope for dozens of harbor designs. Out of all the ruck of cobwebbed plans, Peacock's Garella's, Totten's, the official French, the idealist designs of Sautereau and a dozen compatriots, there emerged last winter two—one that of the majority of the advisory board, the other that of the minority, the commission and the Secretary of War. The official maps, accompanying the board report gave their locations and their text confirmed the maps. Both were of a type in which the breakwater arms run from the shore, northward, converging to an entrance seaward of Colon. They were different from all that had gone before. Every other serious plan had put the breakwaters at right angles to the great wave-making winds. These schemes started a new departure in Atlantic harbor designing.

No explorations or borings were made under the greater part, and that the most expensive sections of these breakwater arms. The east arm was a mile long, the west arm 4½ miles long. No one knew (no one yet knows) where the hard bottom underlies the mud, seaward from Mindi Point for 3½ miles. The formation was unsearched and the mud and sand were unplumbed under one mile of the eastern arm and under 3½ miles of the western arm. No designs were made, no investigations were undertaken, no quantities were estimated, yet the majority, the minority, the chairman of the commission and his colleagues, the chief engineer and the Secretary of War, all set their hands and seals to the solemn conjecture that they would cost $5,300,000.

The harbors recommended by the minority engineers are inclosed by two break-water arms. Both are approximately parallel to the axis of Limon bay, but are toward the east of Colon shore.

The east breakwater is an arm run out to the 40-ft. contour from Manzanillo Point. Immediately off its outer end and only a few hundred feet to the northward is a dangerous

cluster of rocks and reefs carrying but 22½ ft. of water. These in "northers" break heavily and induce a jumble of swift currents and back-wash, hazardous to a steamer seeking haven in dark and stormy weather. The board is united in presenting as a harbor feature this perilous reef right under the lee of wind-lashed vessels. Ships that in storms or blinding rains miss the narrow entrance ought to have sufficient sea room to avoid piling onto such hidden jagged peaks. Safety to navigation should be a keynote in the harmony of the best canal scheme.

Further, the mile-long eastern arm receives the high trade wind waves, driven often by vicious squalls, not at right angles to its axis, but obliquely.

The West Indian "norther" and hurricanes and gales come nearly always not out of the north, but from about the north, northwest. This condition of wave exposure compels, for the breakwater, a large cross section and extra heavy blocks of stone or concrete, else the fiasco of the early Galveston jetties must be repeated.

The Majority indicate a west breakwater 3¼ miles long from Mindi Point. The minority one 4½ miles long from Mindi mouth. The sailing course here is almost due north.

A little reminder of the conditions to be dealt with in Limon bay may be pertinent. Here are the accounts of the "norther" of last Christmas week:

"The Advance arrived yesterday, four days behind her schedule. She should have sailed from Colon on the day before Christmas, but on December 23d (1906), a fierce 'norther' tore her from her moorings, and to avoid being dashed upon the shore, Captain Hammond turned his boat for the open sea. Fourteen other vessels at Colon also were compelled to put to sea. The gale lasted four days with hurricane strength, causing many wrecks of small craft along the coast.

"The Advance found shelter in the harbor of Porto Cabello, Venezuela. Twice during the four days of the storm Captain Hammond vainly sought to work his way out of that port and back to the Isthmus. He said yesterday that the wind arose with such rapidity that he had all he could do to get his vessel safely out of the harbor of Colon. So terrific were the head seas that the ship had difficulty in clearing the roadstead. The wind moderated sufficiently December 27 to permit her departure from Porto Cabello. She

made her way back to Colon, finished her loading and sailed on the following day." The Captain's account gives other details:

"We were scheduled to sail from Colon on the day before Christmas." Captain Hammond said, "but while we were still loading that wind sprung up and we were up against it good. I never saw the glass fall like it did that afternoon, and pretty soon it came on to blow from the northward. You see, the harbor is open to the north, and that puts us with the shore to leeward. The gale increased by midnight and we could see that the only thing to do was put to sea for safety.

"We didn't relish going out in that blow, but there was no other course. It was make for the open or go ashore, and so we decided to save the ship. And we had no easy time, either. It was one thing to head the ship for the open, but it was quite another to keep her head where we pointed it, and before it was all over we thought a good many times that there was something else for us than finally getting the vessel to New York.

"Never saw bigger head seas than we got going out, and if the Advance had been a whit less seaworthy I wouldn't be here now to tell what happened. They swept clean over us at times.

"Had we stayed inside half an hour longer I hardly think that we could have ever gotten out at all. There were five other steamers in the harbor at the time and they all went along with us. We managed to weather the storm, though we found ourselves in Porto Cabello, Venezuela, before we could start back to Colon.

"Had to lie in at Porto Cabello for nearly four days, all the time hoping to get a chance to go back to Colon. Did make two attempts at it, but the weather was too much for the vessel to go into. But the hurricane blew itself out by the night of December 27, and after that we had good weather."

The West Indian "norther" nearly always, as was noted, comes not out of the north, but from about the north-northwest. This is why Toro Point, on the west side of Limon bay, partially shelters the safest anchorage. The charts of all nations show this and all Admiralties officially admonish mariners of it. The following are the official instructions to mariners:

"Anchorage—The best anchorage in ordinary weather is abreast the Pacific Mail Company's dock, about 600 yds. off, but in bad weather it is better to anchor on the opposite side to avoid the heavy sea that rolls in around Toro Point; the holding ground is good, but there are many anchors and cables strewn about the bottom."

"Northers—These winds occur in November, December and January; they are seldom violent, but a heavy sea rolls in."

"At Colon a norther is not necessarily a gale of wind. In fact, the wind frequently does not blow home, and is at times quite light; but very heavy ground swells heave into the bay. When the wind does blow home, as happened during the norther of December 19-21, 1890, no vessel can remain at anchor with safety. There is no way of predicting these dangerous northers. The barometer gives no indication; the 'fitful showers of rain in large drops' may or may not be an indication. The gradually increasing swell, supposed to be a forerunner of a norther, frequently proves to mean nothing.

"The norther of December 19-21, 1890, was preceded on the 18th by a heavy swell and threatening weather, but toward evening the swell decreased, the weather cleared, and it looked like a fine night. Later in the night the swell commenced to heave in with great force, so that the steamers were compelled to leave their wharves. It was not until after daylight on the 19th that the full force of the norther began to be felt, and in a very short time it became so rough that all steamers put to sea. The Pacific Mail steamer Newport, cut her lines and steamed across the bay to the anchorage under the lee of Toro Point, but was soon compelled to abandon this anchorage and put to sea. One steamer lying in the harbor with two anchors down dragged nearly one mile before she could get sufficient steam to be able to slip and go to sea.

"During the season of northers, steamers should keep steam up constantly and be ready to move at a moment's notice. This is the custom of steamers of all nations which touch at this port, regardless of the time they may remain. However long the weather may have been threatening, when the norther does break it comes suddenly and leaves no time for preparations. If compelled to get under way, the surest way is to slip the chain and steam out to sea. It would

be almost impossible to get up anchor without damage to the ship at such times, and there is always a risk of hooking one of the old anchors and chains with which the bottom of the harbor is strewn."

To the shelter of Toro Point, therefore, vessels first scurry from the danger of reefbound Colon.

The eroded shore contours of Manzanillo Island bear evidence of the inroads of past cyclone-made breakers. Did these attested facts and the deep mud bottom mean nothing to the course, design, construction and maintenance of the outer three miles of the west arm?

Crested rollers twenty-five feet high must assail obliquely the three-mile flank of the west arm, founded in mud. Solid twenty-ton rock blocks are not obtainable on the Isthmus with which to make safe these sponsored and half-sponsored and temporized harbor-defending walls. They stretch five miles and a half long. But no one has ventured to even guess at the heights from their crests to the deep unknown mud-buried bases of their outer three miles. Was it meant to bring granite from the States? Were concrete blocks intended? There is neither sand nor cement available. It would take argosies of ships to carry sand, cement or twenty-ton blocks of stone from any source of supply. This was the Atlantic breakwater solution advised by the board of experts.

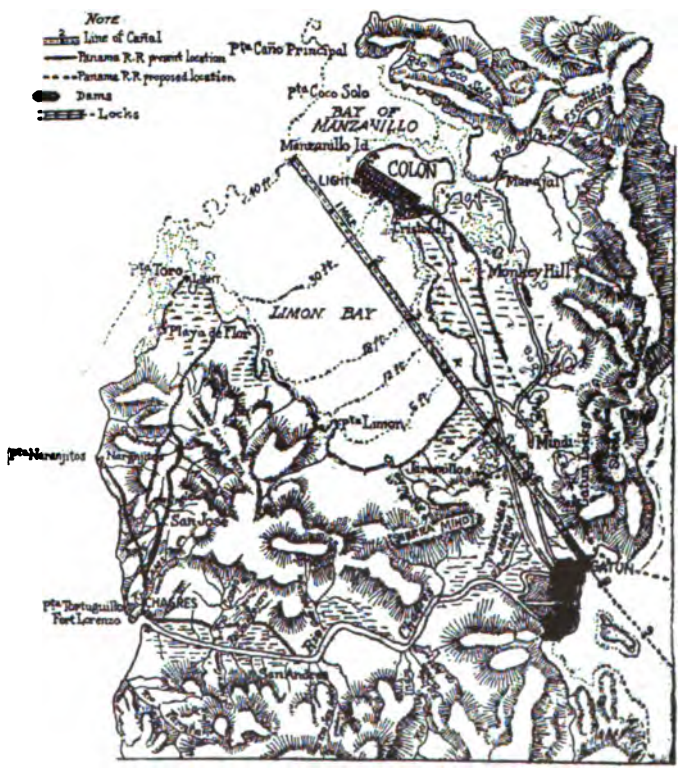
Though the Spooner Act calls for adequate and equipped harbors, the commission presented no design and vouchsafed no detailed estimate to support the allotted $5,300,000.

After these long breakwaters and this reef menaced entrance, they provided here at the Atlantic a salt harbor only and a terminal city, Colon, two miles from the best canal entrance and built over an unfilled swamp. If the terminal were removed under the minority plans to the best site, Mindi, it would remain surrounded by morasses, because their lake begins only at Gatun.

The channel proposed by the minority and commission is but 500 ft. wide. The channel advocated should be wider certainly to the basin below the first lock. Six hundred feet in an exhaustive examination made at Durban, South Africa, was considered by the highest harbor-making authorities the least that should be provided for a harbor entrance channel exposed to such waves. The width much to be preferred here

is 1,000 ft. or more and the writer's Lake Canal provisions arranged for the gradual broadening to this very desirable width.

The Minority of the expert board, after due ponderings, achieved a plan which received eulogistic acceptance from commission, Chief Engineer and all canal authorities. The Atlantic harbor elements have been detailed. The situation was supposedly studied, first by reliable experts; second by combined commission and Chief Engineer. All accepted the described breakwaters, as the harbor solution. The board dissolved. Of the technical men then on the commission three only remain January, 1907. The canal engineering was then in the hands of four professional men. They go at the situation apparently afresh and we have a marvelous new deliverance—



LATEST OFFICIAL MAP, BREAKWATERS DISCARDED.

at least a herald of a marvelous new deliverance. Another map was issued December 17, 1906. Lo, the experts' experting and the commission's commissioning are all gone. There are no breakwaters now at all.

Here on the Atlantic there have been designed therefore five million dollar breakwaters and also no breakwaters.

The omission of this harbor feature from the latest canal picture expresses by implication a belief that a channel 500 ft. wide from Mindi Mouth past Mindi or Hyacinth Point can be made and maintained to the forty-foot contour by dredging alone, and this against such hurricane waves as heave in from the sea and such bottom disturbances as are created in the upper half of Limon bay. One such "norther" would shoal the upper mile or more of the approach channel from forty-five ft. to a dozen or less, and it would take many months to restore navigable depths. A blind channel of this order cannot be maintained continuously. Against the surges of the ocean, could a 45-ft. channel straight in from the sea be made and held at, say, Atlantic City? This is possible only where one can place a good measure of reliance on the ebb-scour of a great tidal prism, as in New York bay, or in the outrush of a great non-silt bearing river. So this cannot be "how the canal will look when finished."

At the Atlantic entrance, five and a third million dollar breakwaters had been decided upon and definitely located by the board and these had been accepted by the commission. The commission contends in the annual report that the 85-ft. design was adopted by Congress in June, 1906. Did it adopt breakwaters, or no breakwaters? It was last decided to throw down breakwaters altogether, which lets the wind and the waves riot at their will, save only as dredges may plow furrows through the underdrift, to pass like children's markings on a beach.

The Isthmian harbors are defended, or left open, not by any defined law and proved knowledge, but gropingly, experimentally and arbitrarily, as one or another policy comes into the ascendant. Is harbor improvement, then, no longer a science with a tested past and an accredited system? Has the world from time immemorial fought the seas and learned nothing of the metes and bounds of her procedure?

The technical history of the Panama Canal, with its boards of engineers guessing and planning, guessing one thing to-day and another thing to-morrow, and defending

with jealous bigotry a half-baked design to-day and discarding and denying it to-morrow—all this will make its engineering story a conspicuous instance of the great power for harm as well as for good that exists in public office. The place invests the man, and the curule chair is still a symbol for inferred eminence.

A commissioner with the authority of the Secretary of War has announced in a New York paper "they may not be required." There is to be thus saved the immediate expenditure of $5,300,000, while the engineers get time to experiment with bucking "northers." That is, they are to get by experience the knowledge which they lack.

Well, some progress has been made albeit negative. The breakwaters of unknown quantities, founded in unplumbed depths of unsearched mud (the original boring notes can be presented), of a vouched cost, though without any determinate evidence and not drawn at all on the momentous map of December 17, may pave the way for one of those late repentances to which the country is growing used. There may be some day another announcement of again changed alignment and again redesigned breakwaters. This would be wise, indeed, for those adopted and incorporated into the previous maps were merely notional.

Let the hope be recorded that there are seen in this last official map the obsequies of the minority design.

This discussion must now refer to a few dominating harbor factors.

An inspection of the head of Limon bay is convincing that Mindi is the best Canal entrance. It eliminates sharp curves and shortens by several miles the total canal length.

Jaramillo Hill is the best location for the right terminal city, and a course nearly centering the bay is the best approach. This location is well away from the dangerous reefs off Manzanillo Island, which remain the perquisites of the last official alignments. It gives a curveless entrance to a Mindi lock and terminal city. The approach points into the eye of the heaviest winds and wave motions, not somewhat obliquely, as does the Minority or the December 17th approach. Were this terminal city adopted and the first lock set at Mindi entrance, there could be created here a double harbor—one of salt water, one in the fresh water of Lake Chagres. The Mindi lock would bring a lake within 3,000

ft. of Limon bay. This disposition would make possible the most perfect harbor combination in the world.

No one would want to live or do business where the present Colon is located, if he could have highly attractive and sanitary conditions and real commercial activity at a city on the Mindi Hills.

It is folly not to put on the steamer's ocean voyage the distance to the head of Limon bay. The canal headquarters and dispatching station should be at a terminal lock here. It should not be at the infected, saturated, distant site of Old Colon.

On the other hand, the navigator will also know that in any plan which seeks to permanently preserve Colon as the terminal city he would be obliged to have the protection of a very costly outer breakwater.

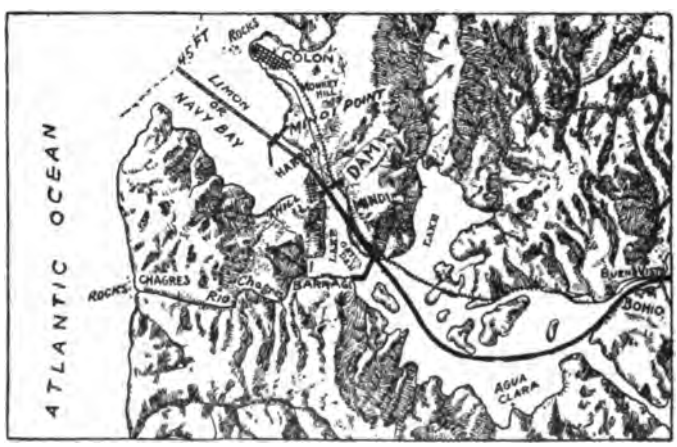
A merchant captain or a naval commander will not wish to exchange the advantages of fresh and salt water havens at Mindi, straight, safe entries, and all that goes with rightly designed harbors, for the disadvantages attending the government locations.

The official chart shows that the shortest and most direct route from the new canal entrance to the nearest point on the 7½-fathom contour would lay the entrance line to a place nearly midway between Toro Point and Colon. This fact has a material bearing upon the location of breakwaters.

The cheapest and best breakwater will be wisely set where it is founded in shallow water, not over twenty feet, and yet incloses an ample salt water harbor area. Such breakwaters would extend from Mindi Point westerly. Mindi Point is about a mile north of Mindi mouth on the east side of Limon bay. Breakwaters thus located would receive their wave shocks at right angles, where they can give their full resistance. They do not, therefore, require the heavy construction demanded by a wrong alignment in the deepest water, where, of course, there must be greater volume to resist the sea. They do not extend one and three and a half miles seaward beyond all borings. They are not experimental and are not in unplumbed depths of mud or sand. Their location is in the known and tested section of Limon bay. These breakwaters are the only ones, therefore, which are not through their greatest extent conjecture entirely. The Mindi Point breakwaters are based on known borings and on

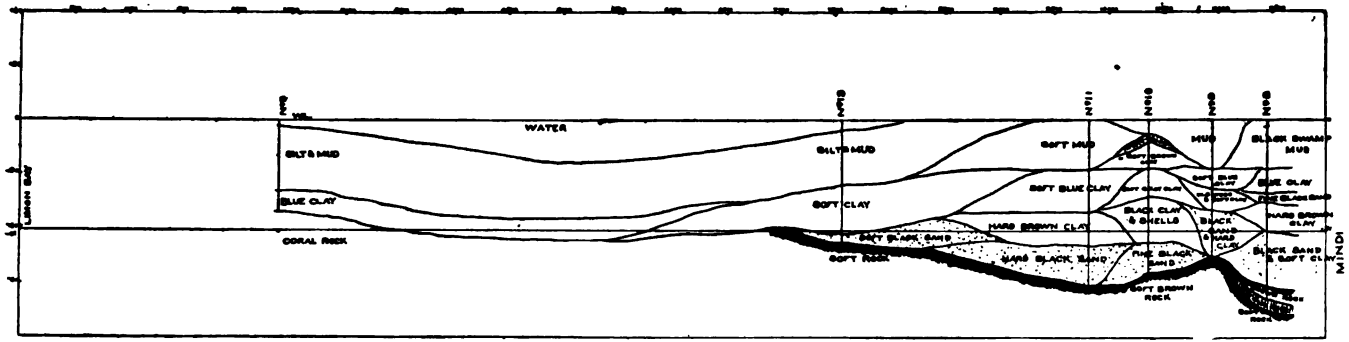
known foundations. Their cost would be but a fifth that of the Minority's and their sum, $5,300,000 was itself wholly inadequate for the structures demanded by the wave conditions which the board's construction had to meet.

What should be the dispositions here? Well, if it be regular, rational, normal harbor improvement, it should be somewhat like this: The channel seaward of Mindi Point, a thousand ft. wide, ultimately, has submerged banks below the plane of wave motion. The bay here is deep enough for sea-going hopper dredges to manœuvre safely, and by such dredges it will be excavated and maintained. Landward from Mindi Point, smooth-water dredges, dipper, clamshell or multiple-bucket machines cannot work without shelter, and sea-going hoppers will find the surges made by the trade winds too high, the bottom too soft and too light and the depths too shallow for safe effective work. So the logic of

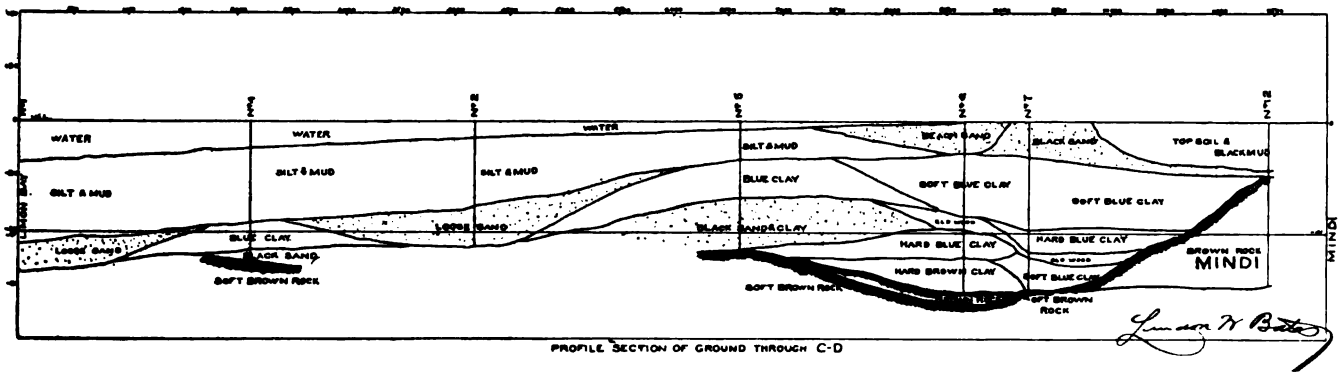


ENTRANCE TO PANAMA CANAL, PLAN OF LINDON W. BATES

the local conditions and the limits of the science of dredging will compel shelter and the employment of smooth-water excavating devices. This shelter will have to take the form afforded by breakwaters at right angles to the side of Limon bay and extending from Mindi Point to the verge of the new channel. The channel width will intervene, and then another section of breakwater will be built to secure smooth



PROFILE SECTION OF GROUND THROUGH A-B



PROFILE SECTION OF GROUND THROUGH C-D

ROCK FORMATION AT MINDI BUTTES.

strangers will have waved "good speed" in the comradeship of the sea. The canal is a waterway, but it is a landway as well between the hemming oceans. Mother Earth will be fair and ground will be pleasant under foot, after the weary leagues of the seas. If the canal features can be made attractive as well as useful, let beauty be allowed. Let the few short hours wherein our Isthmus shall tend her guests be hours to cherish not to dread.

The terminal cities will be the landing places. In them will be mostly centered whatever of life and interest the Isthmus shall offer. For the ship itself and for its human occupants the best conditions must be provided. The terminal cities and the terminal harbors, because they focus the significance of the enterprise, are worthy of the best that can be done for them. Let the waterway have a fitting setting. Let its "hail" and its "farewell" be worthy of a "World's Canal."

CHAPTER VIII.

The Gatun Dam.

Why in the Isthmian lock canal is a dam set at Gatun? This is a natural question, but the answer is simple and plain. Considering the steady expansion of the world's trade and commerce, the present dimensions and drafts of ships, their inevitable increase and the need of water for making the required number of lockages incident to the Isthmian transit—in short, for the adequate service of navigation, naval and mercantile, the summit level of a lock canal at Panama must begin on the Atlantic side at Gatun or Mindi.

If it begins at Bohio, ten miles further up the Chagres, the lockage supply is wholly inadequate; if it begins yet further up river, as at San Pablo, or Bas Opispo, it is too meager to be worth a moment's consideration, aside from other phases of the matter, technical and financial.

The pregnant truth was not emphasized or even realized by the French, because in the early eighties there was little anticipation of the stupendous strides that modern commerce was to take and the great sizes that ships were destined to attain. The canal projected by M. de Lesseps was 28 feet deep, and in his greatest financial stringency he considered cutting the 28 down to 22 feet. Already to-day ships are in existence 788 feet long and of 88-foot beam, and draft is permitted to over 38 feet, and still larger vessels are projected. Insufficiency of lockage water did not demand from our predecessors, therefore, so concerned a contemplation as it does from us. Our earlier commissions, likewise, quite failed to appreciate the coming commerce and the advancing proportions of vessels. As recently as seven months before the meeting of the International Board, the channel, newly recommended by the technical committee, was but 35 feet deep.

The Bates project before the experts gave a diagram of an existing Cunarder in this advised canal. The ship was shown to project nearly two feet below the bottom. Object lessons help along to necessary changes. The International Board was the first technical body to acknowledge in channel depth and dimensions the demands of the world's shipping and of existing and future ocean carriers. It is one of the merits which must be set to the credit of the majority, and

to the minority also except as to lock lengths. It is recorded here with gratification.

The reason for setting the dam at Gatun was, then, that a dam there insured a lock canal with an extensive enough watershed and large enough water supply for all possible future demands. To build a waterway at huge expense and make it inadequate for coming commerce were folly surely. Ample lockage water was recognized as the very sine qua non to any right Panama Lock Canal. Accepting the principle involved, the Minority and Commission set about applying it. They recognized that for this sufficient reason, as well as for others, the dam must be put no further up stream than Gatun. But they failed to carry the logic to its inevitable culmination, and they passed without utilizing them the same capacity possibilities inherent in closing the gaps at Mindi and on the Lower Chagres. It has been mathematically demonstrated beyond question that to secure an ample supply of lock water for the future the summit level for the Panama Canal must begin, as was said, at either Gatun or Mindi. If locks be not put in flight, but separated, these two places are the only sites on the Atlantic where locks can be located. If the canal be made with two locks, one must be at Mindi or Gatun; if with four, one must be at Mindi, another at Gatun.

The whole lock idea has been linked from the first with this question of feed water and a dam. The problem has been dams—Where? The originator of the Gatun Lake plan, Godin de Lepinay, who conceived it, he tells us, in 1859, had a clearer realization of the true principle involved than any of the long line of engineers who, through more than half a century, succeeded him. His injunction shows the master insight, "the barrage shall be placed as close to the sea as the configuration of the land admits, perhaps at Gatun; if not, then certainly at Bohio-Soldado." He presented this idea to the Sub-Committee of the Paris Congress, but it was not considered by the General Assembly. Attention has been called to the report of the American delegates, written in 1879 and published in Philadelphia, in which they comment upon de Lepinay's proposal of this Gatun dam and a lake. These American engineers were present, and they entertained the idea very favorably, though announcing, notwithstanding, that there were no data whatever for passing upon its practicability. The

Advisory Board has vainly and erroneously credited their valuable terminal lake to M. Klietz—Klietz of '79. The French official report and the Sub-Committee Minutes show that M. Klietz was for a sea level, not for a lock canal at all. He presented instead a paper upon the possibility of building a sea level without a tide gate at Panama.

This dam of de Lepinay, projected first, as was seen, for Gatun, began taking on greater and greater proportions. When the 1901 borings gave the coup-de-grace to the Bohio foundations, the dam and locks then located there had to be reconsidered, and the question became where would they be best placed. The world's commerce having by this time declared its prophecies in no questionable figures, moving the dam up stream became impossible, so it had to go down stream to Gatun. This lockage principle has come to dominate the whole lock canal at Panama. If there cannot be a dam and lock at Gatun or Mindi, there cannot be at Panama a lock canal adequate to the commercial needs of America and of the world. The oceans are not supplying reservoirs for the lock types. Rainfall is the source, and the watersheds in the territory supply the feed. Locks must be set where the drainage of a sufficient area above them secures an adequate supply. All these facts are emphasized because the immeasurable importance to the 85-foot design of the mammoth Gatun Dam must be clearly and forcibly impressed. It is the very heart of this whole high-level project.

Another natural question is, Why is the Gatun Dam so colossal? It is colossal because the level of the canal has been set at the great height of 85 feet. A dam which is to hold back a lake 85 feet deep must be huge at best, and it must be, at Gatun, extraordinarily huge, because, in the first place, the gap to be closed is wide; and, in the second place, there are not rock foundations. So the structure, being of "earth" type, must be of vast proportions.

Now, if any one asks the further question, Why was the level set at this great height of 85 ft.? It must be confessed frankly that this is the conundrum. Engineers are asking, more and more concernedly, Why? The high level entails so much and hazards so much, and to what good?

The Panama Canal is being built for the service of ships; navigation itself is therefore the best gauge for heights and depths. Ships are to-day permitted a draft of some 38 ft. As vessels go, therefore, a 60-ft. or a 50-ft. lake would meet

the needs of commerce as amply as the 85-ft. lake. The saving of excavation in the Culebra is not at all sufficient to offset its higher dam and its extra locks. The 85-ft. lake compels a dam 135 ft. high. It also has demanded six locks, three on each slope, to gain the summit. Sites for locks being limited, three were set together in a flight at Gatun, and a most dangerous feature was introduced. So the source of the engineering perplexities and menaces, as well as of the great money deficits, lies in the fundamental and most deplorable selection of an arbitrary 85-ft. level, rather than one at a low plane of 60 or even 30 ft.

Profiles.—Some surveys and borings on the dam site were ordered and were made in the summer and fall of 1905. These are before us in the Report of the Minority, and the Senate testimony of March, 1906. The map is Plate XI of the report, the profile of borings is Plate XII. The original map prepared by the engineer who directed the borings and who signed the profile bears record November 3, 1905. The original blue print was subsequently lithographed by order of the Senate Committee. A comparison of it with that issued by the Minority and the Commission discloses two facts:

The first, of minor importance and of but suggestive interest, is that the scale was changed so that the two subterranean gorges under the projected Gatun Dam looked less formidable to the lay mind. The second is that all data relating to the artesian flow from seven out of the only eight borings, in these two gorges were omitted. The information is fully given on the profile which is signed by the division engineer, but it is lacking in the profile which the Minority caused to be made from this identical blue print, and which they incorporated in their report. The Senate Committee finally demanded and got the original. The profile in question is verified from the record:

Senator Morgan—"I suggest that it is very necessary to have copies of this blue print made for the use of the Committee and the Senate (referring to blue print profile, the original from which this plate twelve was prepared). It is the most important document in the whole case."

The Chairman—"Very well."

Senator Kittredge—"I agree with you, Senator, about that."

The Chairman—"That seems to be the only copy that they have."

Senator Kittredge—"They sent us what purported to be a copy, but it was not."

Senator Morgan—"It is a very precious thing if that is the only copy that they have got, and it should be done at once. I hope that the Committee will pass an order that the Chairman be requested to apply for permission to have it printed."

The Chairman—"If there is no objection it will be done."

This one and only "blue print," "the most important document in the whole case," is here considered.

The borings shown in the Report Plates XI. and XII., and the additional story disclosed in the borings of the "blue print," with the field records, will be analyzed together.

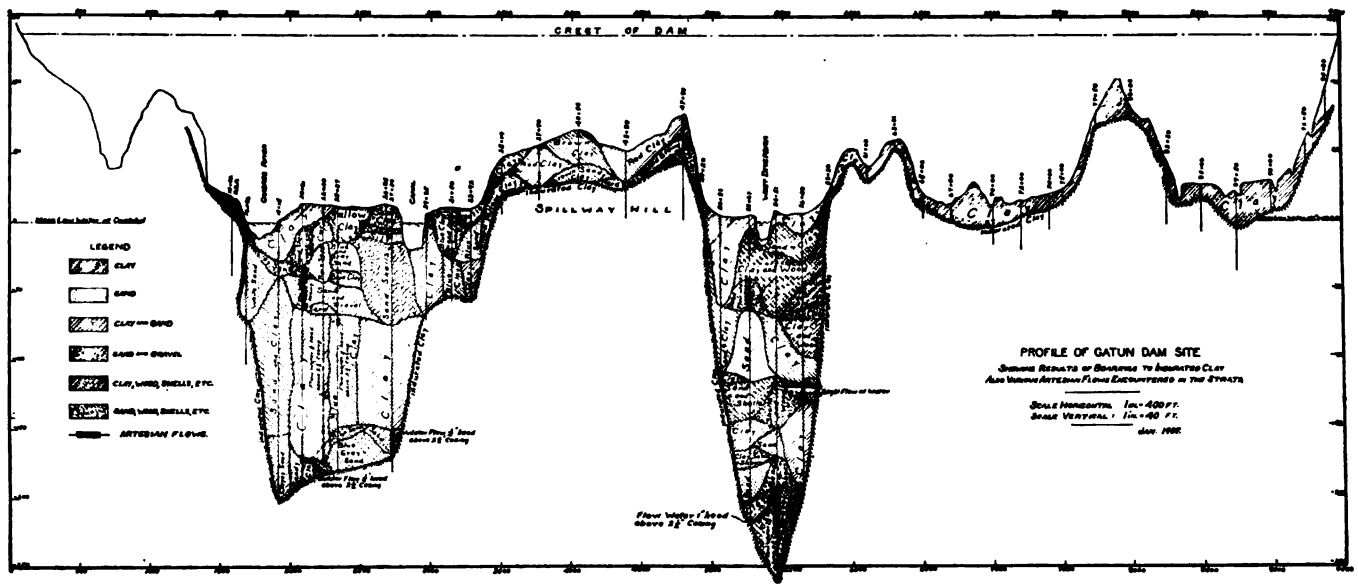
Part of the facts in the case appear to have been casually considered by two of the "Majority" members. There were meager allusions before the Senate Committee. But these engineers seem to have gotten the impression that, while there were some under strata that were water-bearing, this was the worst that could be said of the situation. It was referred to from this relatively harmless viewpoint alone.

The import and the tremendous, far-reaching bearing of the facts seem to be quite unrealized. The conditions will be reviewed as untechnically as possible and the conclusions adduced. Since all deductions are based upon the data, these must be detailed at some length. The factors and local conditions must be set forth before any conclusions can be drawn.

Contrary to the general belief entertained, few borings under the actual dam site have been made since November 3, 1905, when the Division Engineer's Map was recorded (that is for the fourteen and a half months to January, 1907), except in Spillway Hill, a knoll of some fifteen acres in area, midway between the locks and the west abutment of the dam.

Thirty-seven borings in all were made on a preliminary axis for the dam, of which one, being probably defective, has not been counted. Thirty-six is the number given between the locks and the western hill, in the annual report of 1906. Of these there were but three in the whole area of Spillway Hill. Not one of the thirty-six had been driven on the actual site of the paper location for the vast concrete works of the spillway. These constructions were vital ones, since they were to control the lake level and the whole Chagres flood, and they were speculative entirely.

The Spillway was estimated to cost $2,608,000. Its great concrete works were to contain 189,000 cubic yards of masonry, and the figures were $1,512,000.



PROFILE OF GATUN DAM SITE.

The borings on which a work to cost over two and a half millions was vouched were located as follows:

One bore is 150 feet north of the north end of the concrete apron. Two are respectively 275 and 300 feet away outside of the north toe of the apron. There were no others reported in the hill, so the Minority and Commission estimates were the sheerest guesswork, as the thirty-odd holes now reported were made long after.

The record of these borings went to the Senate Committee January, 1907, in response to a request for the year's tally of underground explorations.

In Spillway Hill no borings were given between a line connecting stations 40 plus 50 and 47 plus 90 and the south toe of the spillway—a distance of 740 ft.—nor for some 700 ft. south of this line. This was a most crucial area of fourteen acres, which was to be dug out and filled with concrete and mechanism. The Minority conjectured that its excavation involved 1,100,000 cubic yards of earth and 480,000 cubic yards of indurated clay. Self-evidently they had no warrant of ascertained facts. Now the thirty-six bores in Spillway Hill are reported satisfactory.

Gatun Dam Borings.—We turn to the 36 or 37 bores, on the showing of which the mammoth Gatun Dam was located in 1905 by the members of the Minority, was accepted by the Commission, the Chief Engineer and the Secretary of War, and was assured to the public as safe and certain of construction and of stability. All the other holes, save four of the "sixty-three" bores last reported to the Senate Committee, are outside the limits of the main dam shown on Plate XI. Some are over half a mile distant.

It will be recognized readily that in a great construction like the Gatun Dam the mass, volume, weight and pressure are greatest under its highest point—that is, under the crest. This dam is at its crest 135 ft. high. It slopes, first rapidly, then gradually, away down stream for half a mile, where its base merges into the valley. Its most crucial problems therefore are represented in the belt directly under its crest, not in other belts. An examination of the map will show that the tentative axis is distant from the crest line in the center quite 442 ft. The preliminary or tentative axis on which most of the boring has been done is different from the axis of the finally located crest. The relation of this preliminary axis to the axis of the crest is well illustrated by a bow and

its string. The curved bow is the tentative axis and line of borings; the string marks the crest axis.

First, as to where the borings are and where they are not. The total length of the dam structure exclusive of the lock site is 8,640 ft. On the entire dam site east of the locks, a distance of 940 ft., no borings whatever were made. On the first 1,025 ft. west of the locks no borings whatever were made.

The total distance eastward from the locks before a boring is struck on the crest axis is 2,295 feet, or over two-fifths of a mile. On Gatun Island there are five bores, reaching to the bottom of the east geologic Gorge.

At Station 19 plus 15 indurated clay is struck at 205 ft., and at Station 27 plus 30 indurated clay is struck at 187 ft. below sea level. The bottom width of the Gorge is about 815 ft. Four of its holes reached to the indurated clay, one did not.

Station bore 22 plus 40 did not reach indurated clay nor did 26 plus 85. Both of the last two holes are north of the dam crest about 260 feet.

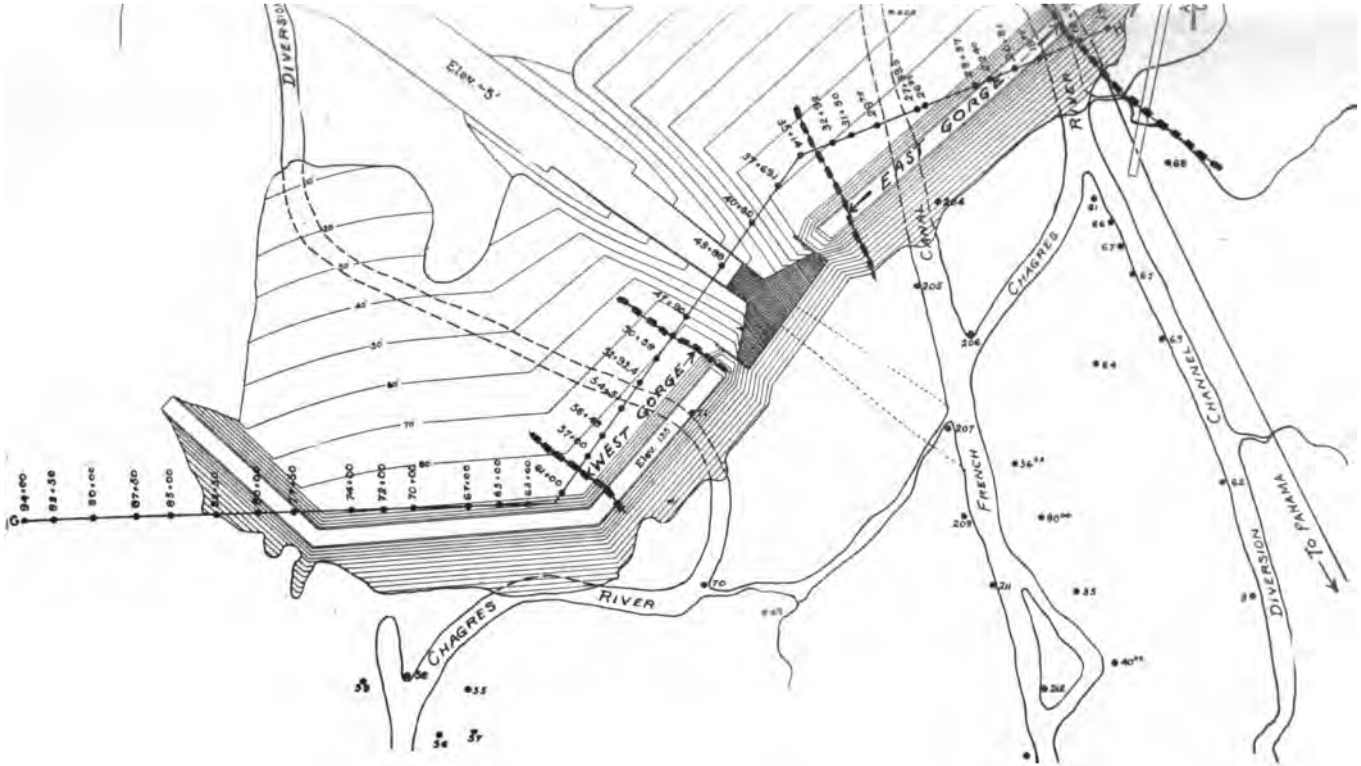
Of the thirty-seven bores presented on Plates XI. and XII. and the Blue Print, there reached clay rock and stopped, 5; reached clay rock and penetrated a few feet, 30; did not find rock, 2.

From Station 23 plus 27 to 77 plus 50, and for about 5,400 ft., or over a mile, along the crest axis, there were no borings.

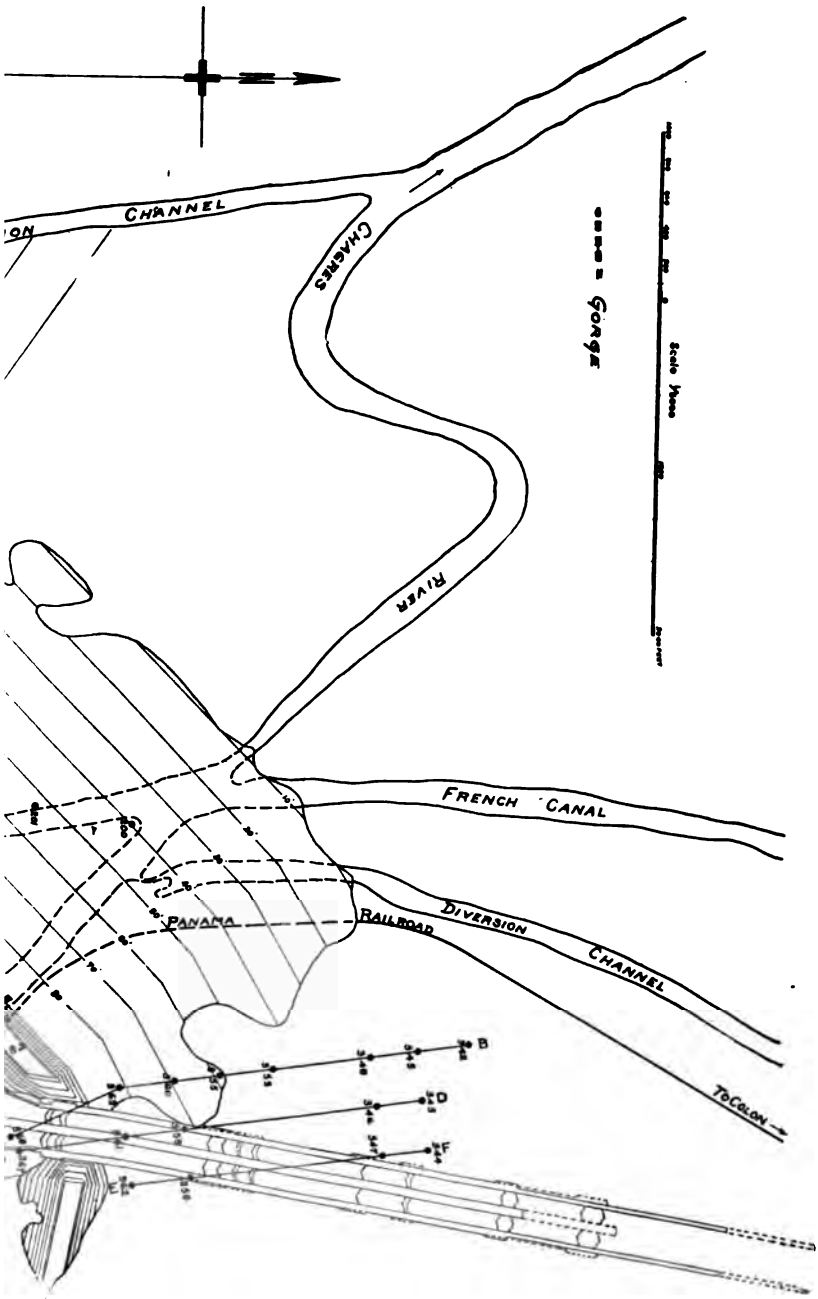
From hole 77 plus 50 to the west abutment, northwest a distance of 1,000 feet, there was not a single boring. The nearest is at station 80 with indurated clay at 75 ft. above ocean level and 200 feet away from the crest, another is at Station 82 plus 50, which is 300 feet distant. The bores at Stations 85, 87 plus 50; 90, 92 plus 50 and 94 are from 500 to 1,100 ft. distant from the crest—away to the southward. From Stations 61 to 77 plus 40, a distance of 1,650 ft., there are seven holes, on a line about 200 ft. north of the axis of the crest.

There are actually in 8,640 ft. under the located crest of this massive structure only three borings. Two are in one place and one is at another, over a mile away. Next, near the two mentioned above, there are two other borings on the slope of the crest, and there are no further holes anywhere within two hundred feet of the crest axis.

South Foot of Dam.—There is but one boring along the



LOCK CANAL PROJECT, VICINITY OF GATUN, SHOWING LOCATION OF PROPOSED DAM AND LOCKS.


CHANNEL
CHAGRES
RIVER
Gorge
FRENCH CANAL
PANAMA
RAILROAD
DIVERSION
CHANNEL
To Colon
B
D
F

south toe from the east to the west abutment, and that is on the hill at the west end. This is the only boring given in 7,700 ft.—and there is but one other, No. 204, into the east gorge, which is not published.

North Slope of Dam.—North of the line connecting the trial axis in a belt from 2,000 to 2,600 ft. wide from side to side of the whole valley—there is again not one boring. Outside the dam site three holes were sunk over the east gorge, near the north end of the island, on which is the native village of Gatun.

Of the full 37 bores ten only were in the gorges, and of these two did not go to rock—that is, were incomplete. Of the eight left seven were artesian. Three in the West Gorge were artesian out of three sunk. Four in the East Gorge were artesian out of five sunk. The fifth was in the clay rim of the gorge, not in the chasm proper.

In summary, then, of the gorge situation, excepting the one bore driven into the bank, every hole in the gorges was artesian, forcing the water (allowing about 3 ft. for the casing) to a height from 8 to 17 ft. above the river. The river level at low water is practically sea level. Of the four holes which reached rock-clay in the East Gorge two did not penetrate the clay rock. One penetrated three feet, the other about fifteen feet.

Of the four holes in the West Gorge two penetrated only two feet and two penetrated only six feet into the indurated clay, as the Senate profile shows.

In a cable of January 12, 1907, the chief engineer reports: "Pervious material in only four holes, and these below 200 ft." Evidently this is a serious error, as the Senate profile of November 3, 1905, giving the field notes of the Gatun, borings, is as follows:

List of Artesian Flows with Particulars Encountered at Gatun Dam Site.

No. of Hole.	Size of Casing.	Height of ground above mean L. W.	Depth of water flowing over top of casing.	Remarks. Where met.
20 + 81	2½ in.	+13.8 ft.	¼ in.	Flow between (—31) and (—62)
20 + 81	2½ in.	13.8 ft.	¼ in.	Flow at (—171)
22 + 40	2½ in.	12.5 ft.	¼ in.	Flow at (—124)
23 + 37	2½ in.	11.8 ft.	¼ in.	Flow at (—72)
27 + 30	2½ in.	12.0 ft.	¼ in.	Flow at (—151)
52 + 67	2½ in.	3.8 ft.	¼ in.	Flow between (—42) and (—65)
52 + 67	2½ in.	3.8 ft.	1 in.	Flow at (—215)
54 + 51	2½ in.	6.5 ft.	1½ in.	Flow between (—192), and (—230)
56 + 48	——	5.1 ft.	Slight flow of water.	Flow between (—118) and (—132)

CHAPTER IX.

The Artesian Gorges and Underground Chagres at Gatun.

In the writer's volume on the Panama Canal, published in 1905, the Chagres River is in detail exhaustively considered. The data of the Chagres were carefully collected by the French, and certain records regarding its regime dated much earlier. Its volume, rainfall, flood rises, etc., were reported quite independently by the American engineers, so there is a reliable body of facts to be built upon. It was conclusively demonstrated from all available hydraulic data that of the rain falling in the valley of the Chagres above Bohio nearly 53% runs off through the river. This leaves 47% to be accounted for by evaporation and underground travel to the sea. Below Bohio there are 500 square miles of watershed, with nearly double the average rainfall of the area above Bohio. Taking the same ratio for the Lower Chagres Valley, it may be assumed as applying broadly to the two watersheds of the Isthmus—that draining to the Atlantic and that of the Rio Grande and other streams draining to the Pacific. It appears probable from all evidence that 7% of the rainfall is a high figure for evaporation in this climate. It would then follow that of the rainfall at Panama 53% runs off by the river, 7% per cent evaporates, 40% goes into the ground and through the ground to the sea, along the lines of the least resistance.

The ocean is the great reservoir of the continents. It is shown in the writer's 1905 publication treating of the Chagres that 8,500 cu. ft. per second, on the average, pass Gatun through the surface channels—that is, the rivers. If 53% is 8,500 c. f. s., 40% is, roundly, 6,400 c. f. s. This latter volume is, for a picture, that of a river 640 ft. wide and 10 ft. deep, flowing at the rate of nearly half a mile an hour. This average amount is moving down very slowly toward the ocean through the ground every second of the year from the valley of the Chagres and its tributaries.

Part of this subterranean flow goes through and under the hills and mountains. But the hills are of volcanic formation and are mostly clays, worn cone-shaped by weathering and rain erosion. These clays are relatively impermeable. On the other hand, the thousand or more borings made between Gamboa and Gatun during the 25 years of canal build-

ing demonstrate that there is a geologic gorge under the main Chagres trunk. This is 30 ft. deep at Alhajuela, 60 ft. deep at Gamboa, 168 ft. deep at Bohio, and from 204 to 268 ft. deep at Gatun. It is also certain, geologically, that this main gorge has lateral gorges under every large ravine. The borings all agree in showing that the upper clay strata in which the surface water-courses run are underlaid by strata or bodies of sand, gravel, shells, decayed wood, blue sand, gray sand, sandy clays, etc. They show also that the bottom strata of these underground canyons are especially permeable. The consecutive permeable strata are separated by layers of nearly impervious clays. These buried canyons are wide as well as deep.

The main gorges and their feeders constitute a natural conduit system which manifestly offers the line of least resistance for the tremendous volume of water, which is represented by 6,400 cu. ft. per second, or whatever part thereof takes this easiest outlet to the sea. Indurated, or practically impermeable clays, form the bottom and sides of this conduit system, the length of whose trunk and branches reaches hundreds of lineal miles. They drain a watershed of 1,380 square miles, in one of the rainiest countries on the globe. These miles upon miles of underground conduits are saturated to repletion. Further rainfall surcharges them and compels the downward flow. The volume of water must be truly enormous.

The rainfall has been carefully computed to average nearly 10 ft. per year. Figuring not the surface (i. e. the river) proportion, but only the subterranean drainage for 400 years, would give 1,600 ft. If the water which went into the ground from rainfall had not reached the sea since the days of Columbus, but had been barred back, one may say roughly, to illustrate, that the Isthmus would now be submerged under 1,600 ft. of water. The drainage, of course, did reach and discharge itself into the sea continuously, since the Isthmus is there. Most of the subterranean drainage went via the great main artery of the underground Chagres—ever flowing, ever flowing, while the wet and dry seasons passed over the surface stream in recurrent floods and low water periods.

It has been the aim in this series to estimate and deduce conservatively. As the stupendous proportions of the underground water system at Panama seem little comprehended and the subterranean water conditions appear to have occa-

sioned misgivings chiefly for seepage reasons and have never been reckoned with otherwise, they must be clearly and completely established. To fully impress these facts they will be further gauged by comparison with other localities.

Australia is a great continent, with only a rim of arable land, and its whole interior a continuous unbroken desert. Rivers are few, and the steadily flowing streams are nearly all contained in the narrow coast belt. The interior is almost rainless, and water is the jewel of great price.

Mountain Australia, however, is a region of mineral richness and in the zone between the arable coast and the sterile desert—the Never-Never Land—lies the grazing country where sheep in enormous numbers are raised for the world's markets. The prospects of this industry balance yearly in the meager rainfall. Is this sufficient to insure the grassy growths and to water the herds—there is prosperity. Does the rain fail—the sheep die off by thousands, in the last great drought just closed, by millions. In these dry periods begins the great "trek" over the long trail to other feeding grounds, and stations are established along the ways, where at great expense artesian wells have been sunk, bringing up from the depths the water indispensable to the lives of man and beast. There are regular routes, too, across much of the inland desert, with stations a day's ride apart and at these stations are artesian wells. The dearth in Australia of agricultural lands, the enforced installment of grazing as the great industry, and the close margin between gain and loss, existing always in the possession of water—these together have conspired to make Australia probably foremost of the world in experience with underground conditions, as it is first in the world in the importance to life of its artesian formations and its wells.

The evidences of Australia will be herein noted, because, if practically limitless volumes of subterranean water exist to-day under its deserts, how sure must be the volumes, in a land of such torrential downpour through nine months of the year as characterizes Panama?

The writer knows at first hand the surface hydrology of South Australia and Queensland and something of the under conditions. He quotes from an authority on Australian wells, Mr. G. Cox, C. E., A. S. C. E., London:

"Some of the most successful bores are those made at

Hergot, Coward and Atrangways, in which was obtained at the respective depths of 342, 308, 365 ft. with outflows of 1,000,000, 1,200,000, 1,200,000 gallons per diem in each case. These large outflows at such comparatively shallow depths are extremely satisfactory, and in their similarity to the shallow artesian borings at Uanda Station (Queensland) and in New South Wales and the United States prove artesian water does not invariably lie at great depths, but in some localities it is easily obtainable."

It will be recalled that the bores in the Gatun Gorge gave artesian outflow through the depth from 31 to 268 feet.

Regarding a proposed limitation by law of the amount of water to be drawn from artesian wells in Queensland, Mr. Jack, government geologist, speaking before the Australian Association for the Advancement of Science January 16, 1895, said:

"The amount of water contributed to the water bearing strata of the lower Cretaceous formation every wet season by such rivers as the Darling" (the Darling Downs are famed for their extensive ranches) "is so great and consequently the amount of leakage into the sea is so vast that the quantity abstracted from the artesian wells, large as it is, even if it were ten times greater, is insignificant by comparison. Finally the leakage into the sea is so vast and is so entirely beyond human control, the draught on our underground supply by artesian wells is not worth controlling," i. e., limiting by the proposed law.

"It is not because the rainfall is so scant that the western river system of Australia runs dry half the year, but because so much of it sinks into the ground."

In the 1891 report of the Water Department of New South Wales Mr. Boultee, an eminent scientist, says:

"The question of bores has been for years before the department, attention being in the first instance drawn to it by a successful artesian well sunk on Kallara Station. This well was sunk in the proximity of a mud spring and at a depth of 140 feet artesian water was tapped that rose twenty-six feet above the curb, and has been flowing without interruption ever since."

The flow above the curb at Gatun is from eight to seventeen feet.

There is another general district where dearth of rainfall and consequent scarcity of water has assumed a great im-

portance. This is the section through the belt along Central Arabia, Beloochistan, Afghanistan and somewhat northward. It is just beyond this district that the region lies from which the great European migrations are supposed to have come. It, too, was a grazing land and local conditions of pressure drove its population in many waves out and over the interlying stretches to fall upon watered Europe. We quote:

"The utilization of underground water is a leading fact in the history of Oriental regions, and its importance can be realized by an illustration from one country alone. The plateau or high table land region which forms the greater portion of the peninsula of Arabia is without a single perennial stream or body of surface water. A population of 12,000,000 resides therein; large quantities of wheat, durra, barley, millet, beans and tropical fruits are grown on its high, apparently dry, sterile plateau. Ninety per cent of the water supply which produces the present fertility is drawn from below the surface by means of old bored wells. The striking fact in all of Central Arabia is that of underground water supply. Throughout the eastern part of Oman in the Persian Gulf. and especially in the villages of Kaseen, as an illustration of the character of these supplies, it may be stated that there are forty wells, the flow from which maintains a population of 30,000 persons. The depth of these underground supplies ranges from 15 to 200 feet."

And again regarding the Eastward belt:

"In Sind, Beloochistan, Cashmere, Afghanistan, Persia, Chinese Turkestan and in Russian Turkestan, the utilization of ground waters has always played a most important part. A vast system of natural underground conduits exists throughout the regions named, especially in Persia, that carry the drainage waters of the foothill regions for long distances, until they debouche upon the less elevated plains below. So enormous is this supply that vast populations have for many centuries past been supported from the fields that were quickened by the application of such waters."

Algeria, on the border of the Sahara, is likewise largely dependant upon subterranean sources. The artesian experience here verifies the same abundance.

"The government wells in Algeria, some of which have been in use for thirty years, have never decreased their discharge; on the contrary, there is rapid increase in the total water supply."

Turning to countries like England, the saturated condition of the underground is, of course, more marked. One of her prominent geologists writes:

"It has been found that each square mile of dry upper chalk one yard in thickness contains nearly three millions and a half gallons of water, but the same quantity of rock is capable of absorbing, and it would contain, if saturated, upward of two hundred millions of gallons."

America reveals a similar subterranean condition. Professor Hicks of Nebraska reports circumstantially on the conditions prevailing in his State—the direction, the flow and the pressure of subterranean waters:

"Nearly all such waters in Nebraska have a tendency to rise in the wells and sometimes throw out at the surface."

He considers the rainfall the ample source of his suppiy. The aggregate volume of such precipitation is enormous. It amounts, he says, "to more than 100,000 cu. ft. in each acre, or 5,000,000,000,000 of cu. ft. annually for the whole State." The mean discharge of all the rivers in Nebraska is estimated at nearly one-fourth of this great total. Evaporation and seepage absorb the balance. However, the "underflow along the inclined bodies of porous rocks is undoubtedly a more important source of moisture than all the rivers which enter the State." "The existence of great levels of this sheet water has been determined and demonstrated. Many streams have a steadier volume in their channels than the precipitation and their incline warrant. It is believed that they are eroded deep enough to receive a supply of this undersheet flow." The Chagres River, down stream from Gatun, has eroded 27½ ft. below the bottom plane of the clay capping which covers the artesian strata under the proposed great dam.

In the Pennsylvania oil fields a first bore was Drake's well, and this was one of the wonders of the period. When oil was struck, the production of the famous boring averaged between three and four thousand barrels of oil per day. "The sight was probably the most remarkable of a lifetime. From the mouth of the conduit pipe the oil and gas came forth with terrific power, propelled by nature's hydraulic forces."

"In the upper part of Kern county, just south of Tulare Lake, Cal., there are about forty of these great wells within a radius of ten miles, none of which yields less than 1,000,000 gallons per day. The largest, whose flow ranges from 1,200,-

000 to 2,500,000 gallons, gives a total flow each twenty-four hours of 23,600,000 gallons. The average depth of the upper, or more northern wells, is about 350 ft., ranging from 250 to 460 ft."

The discharge of subterranean water occurs, of course, wherever the permeated layer opens—be it in wells or river channels, or be it in the ultimate delivery into the ocean.

"This underground flow and escape of fresh water into the sea, and that often in large quantities, is evidenced by Humboldt's description of a submarine spring in the Gulf of Mexico, some considerable distance from the South American coast, which converts so large a space into a fresh water lake that it is inhabited by the fresh-water cretaceae found in the Orinoco; also an abundant spring of fresh water rises in the Indian Ocean, 125 miles from Chittagong, Bengal, and 100 miles from the coast of the Sunderbunds."

For conservatism the evaporation in the beginning of this study was assumed as high as 7%. The great liberality of this percentage is attested in the following record in dry Australia parching under its tropic sun:

"It is impossible to say exactly how much is lost from the ground by evaporation. We could tell approximately how much was lost from the rivers, but the investigation of the loss from the soil (or vegetation) is a very difficult matter for reasons which might be easily explained. So long as the surface soil is wet the evaporation goes on from it rather faster than from water, but as soon as the soil dries down half an inch—which does not take long—the evaporation from it practically ceases, the layer of dry earth seems an effectual covering to the water below; it is obvious, then, that the evaporation from soil does not go on at the rate which many persons suppose it does, and I am quite convinced that its source of loss does not seriously affect the underground supply; once the water has sunk into the porous soil it is safe."

The existence at Panama of vast volumes of subterranean water is, in view of all the foregoing, taken to be beyond dispute. Next, what are the elements of artesian condition? These are well known; Dana and Giekie are authoritative on geology. They will establish the elements.

"An artesian well is simply a bore sunk into some permeable stratum in which water is under such high pressure that when it is reached the water rises toward the surface, the upper limit reached being determined by the height of its

head or source above the mouth of the well and the amount of frictional resistance it has to overcome."

"Wherever subterranean water flows between nearly impervious sloping layers, so that it is confined to a given channel, it is like the water in a long inclined tube, and on opening a hole through the overlying material it will rise in a jet owing to hydrostatic pressure. The height of the jet so produced is that of the source, diminished by the loss of friction and the resistance of the air." "The presence and plentifulness of artesian water depends on the rainfall in the higher regions, on the lower altitude of the bore site and on the permeable strata between.

"Rain falling on the outcrops of the pervious beds, which are overlaid by permeable strata, percolates in the direction of the bedding planes, and accumulates until each porous stratum becomes saturated up to its outcrop. It is obvious that this imprisoned water must be under hydrostatic pressure, which necessarily increases with the depth and reaches a maximum in the center of the basin. Were a boring made through the uppermost impervious stratum into the subjacent water-logged bed an uprush of water to the surface would ensue. When an artesian well is sunk, the water does not always rise so high as might have been anticipated even after allowance has been made for frictional resistance." "It must not be supposed that basin-shaped arrangement of the strata is essential for the formation of artesian wells. Any series of impermeable and permeable beds dipping continuously in one direction for some considerable distance, may contain abundant supplies, which under certain conditions can be reached by borings." The latter describes the condition prevailing at Gatun.

"The force of the flow of subterranean water is due to gravity like the flow of surface waters. There is everywhere hydrostatic pressure varying directly with the height of the supply minus the loss by friction and capillarity."

Another geologist writes:

"To form an idea of the common class of flowing wells, imagine a pervious stratum through which water can readily pass. Below this let there be a water tight bed, and let a similar one lie upon it so that it is securely embraced between impervious layers. Suppose the edges of these layers come to the surface in some region. Now let rainfall and surface

water penetrate the elevated edge of the porous bed and fill it to the brim. That such beds are so filled is evident by ordinary wells, which commonly find a constant supply at no great depth. Now, it is manifest that if such a water bed be tapped by boring at some point lower than its outcrop, the water will rise and flow to the surface because of the higher head on the upper edge of the bed. If the surface water continually supplies the upper edge as fast as the water is drawn off, the flow will be constant."

Cox summarizes from the Australian conditions:

"My belief is that artesian water is movable along 'water sheets' or travels in channels or 'underground reservoirs' and that this is evident from the fact of the water upon being tapped rising to the surface so freely and with, in most cases, the great force and great velocity and volume that it does, which conditions could not exist if the water issued directly out of the water-bearing rock instead of flowing in a channel formed by its passage, out of that rock.

"The exposed areas of the outcrops or intakes of the water-bearing rocks are very much greater than was at first supposed, and an additional supply—previously unthought of—is provided by rivers and creeks which cross those outcrops, and which must enormously increase the general subterranean supply, bringing water as they do from large areas of the country independent of that confined to the outcrop alone of the water-bearing rocks."

The elements of the artesian situation are then:

First—Pervious layers between impervious layers.

Second—Contact of pervious layers at their exposed surfaces with a water supply.

Third—Hydrostatic pressure due to a greater height in source than in delivery.

Are these conditions fulfilled at Panama?

The borings demonstrate and announce the first. The saturation of the previous strata evidences that it is in contact with a rain supply. The height of from eight to seventeen feet in delivery shows hydrostatic pressure from above. So the general artesian condition is plain.

The Divisions of the Conduit.—At Panama, in addition to the incessant flow through the great Central Chagres conduits—there is another factor. The cross profile of the Gatun Gorges abundantly discloses in

the testimony of the borings the existence of nearly horizontal divisions in the two great arteries, which must be regarded as continuations of the one disclosed at Bohio, Buena Vista, San Pablo and Gamboa.

The divided or bifurcated conduit has a phase of great importance. It has several impervious layers of irregular depth, with very permeable and fully water-saturated strata of sand, gravel, etc., lying between these. The nearer the sea the finer is the sand, and the more in character is it quicksand, and the denser are the nearly impervious clays, overlying these deposits of remote geologic time. The heavier particles, waterborne, were, of course, deposited upstream and in the expansions of the old river bed, especially between Gatun and Bohio, where now there are ten miles of swamps, with island hills emerging here and there. These swamp areas (once lakes) particularly favored the deposits of sedimentary clays, covering and sealing the conduits and sometimes dividing the conduits into several sections by various horizontal layers of the different colored clays revealed in the borings. The sides of the gorges would also be clayey, just as every river bank is characteristically clayey, though the bed proper be sand and gravel. So we have really divided conduits, i. e., the two gorges, leading from hundreds of conduits in the upper reaches, wherein the slope is too steep for the clays to deposit, except along the banks, where the current is checked by friction to the depositing condition. Of this situation Dana remarks:

"Subterranean waters do much efficient work in a quiet way by the transportation of sand along the course of the streamlets that have their outlet at the base of bluffs."

In the Isthmian case the conduit leads on the main Chagres from above Alhajuela, where there is a rocky bed, to the sea. The depth of this main underground conduit at Alhajuela is 30 ft.; at Gamboa it is 45 ft.; at Bohio it is 168; at Gatun, as is seen, the conduit is double, one branch being 204 and the other 268 ft. deep. Below Gatun the valley becomes narrower, but its gorge depth is unknown. James Geikie, whose pre-eminent place as an authority on geology needs no word, writes of this situation:

"In countries where the rocks are of variable character and structure, underground water may be discharged at many different levels, in mountain regions and low grounds alike;

not infrequently, indeed, copious springs of fresh water coming from such regions issue on the floor of the sea. The various divisional planes of rocks—joints, bedding-planes, faults, etc.—naturally constitute the chief underground waterways. In the case of soluble rocks these waterways become widened, by the chemical and mechanical action of the running water, until very considerable tunnels may be worked out—giving passage to torrents, streams and rivers. Relatively insoluble rocks are not, of course, traversed by subterranean channels of this kind, but if sufficiently porous, they frequently contain enormous stores of water. When such beds are inclined and underlaid by impermeable strata, the water they contain naturally makes its way downward in the direction of the dip."

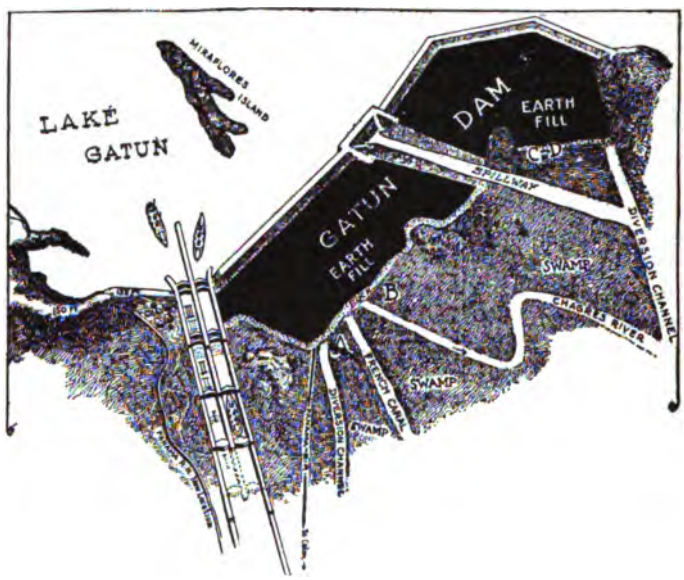
The Panama levels show that the top of the conduit is 92.4 ft. at Alhajuela, and this may be taken as the top of the great underground "pipe" of the Chagres. A large number of borings through the nearly twenty-five years have been made into the gorge between Gamboa and Gatun. Many of these are testified to as flowing bores, thus proving artesian conditions in Bohio, Buena Vista, etc. A member of the American commission which had the largest number of up-river borings reports as follows:

"The same result has been seen time and again in connection with our borings at the Bohio site and above. Some of the borings would not show any water flowing out of the top of the pipe and other borings would show them. It is a rather ordinary feature of our usual experience in boring at that site." That is, the water has risen in the boring to a height of its head, less friction, etc., under the well known hydrostatic law. From the seven artesian borings into the Gorge conduits under the Gatun Dam the water rises quite independently of the Chagres flowing past to a height of seventeen feet above the river at low water or sea level.

If the entire dam site could be made a pit to bedrock at a stroke, the valley would be flooded by the enormous flow of the hundreds of miles of conduits leading underground from the remotest gulches. This is the hydraulic situation in the Gorges over which the Gatun Dam is to be built.

All the foregoing shows that at Gatun now we have:

First.—A surface stream, the Chagres, with an average flow of 8,500 cubic feet per second; to illustrate—a stream of



ARTESIAN GORGES AT A-B AND C-D. PROJECTED 790-FT. LOCKS AND 1,000-FT. LOCKS IN DOTTED LINES.

water 425 feet wide and twenty feet deep flowing 3,600 feet, or nearly three-quarters of a mile per hour.

Second.—The focusing of the widespread underground river system, far larger in section and slowly discharging the part of 6,400 c. f. s. which follows this conduit to the sea.

Third.—An artesian condition in which the water rises from eight to seventeen feet above the low water surface of the river.

There are in the Gatun hydrologic situation finally two other features to which reference has still to be made. They are:

A—The bed of the Chagres, below Gatun.

B—The conditions at the Mindi Gap, close to the Ocean.

At Mindi Gap there is no underground geologic conduit. Access to the sea is sealed between Jaramillo and the Mindi Hills. Impervious, indurated clay is found all the way across the Gap at about 20 ft. below sea level. At Jaramillo Hill on the West side the rock cliff extends 70 ft. above water.

These facts were developed by many French borings and by the French works, which have laid bare the strata here. The surface Chagres is partly diverted into Limon Bay through the French Canal, the underground Chagres must go down to the sea somehow.

Ample hydrographic data here would be exceedingly valuable, but we know of but one map of the soundings in the lower part of the river.

Two millions were authorized by Congress, as has been noted, to purchase all the French studies and explorations. If these had been adequately examined we might have more knowledge than we to-day possess. When the Board Majority and Minority were on that still trail for M. Kleitz—Kleitz of '79, from whom they got their terminal lakes! why did they not look to see if perchance he did not also make some soundings in the Chagres? Two millions are a lot of money for studies and maps. There might have been more laurels due M. Kleitz.

The writer knows of but one hydrographic survey of the Chagres. Fortunately it was made by two competent men. It shows that before the French Canal diversion was opened the Chagres was very deep in certain stretches. Soundings from 50 to 60 ft. in depth were recorded in the four-mile reach beginning 2,000 ft. below this Gatun Dam and extending to San Andres, which is itself 2¼ miles from the sea. In this lower 2¼-mile stretch the river shoaled to 18 ft. The valley has here less than half the width it has at Gatun between the 50-foot contours. Some of the French geologists thought the lower hills might be a later uplift, and very much evidence bears out the belief.

These two men, appreciating what an important bearing the Chagres channel might have, undertook to map its bed. One, a prominent hydraulic engineer, had been originally a mining expert, and he was especially fitted to examine geologic conditions and to estimate river data. He attests of the younger man: "He acquitted himself of this work with zeal and an ardor worthy of praise." The map was published under Government auspices. The two men together took soundings every sixteen feet. They found 50 ft. of water in one place but 2,000 ft. below this great dam, and greater depths, even 60 ft. at several points beyond, where the Chagres Valley has, as was said, but one-half the width obtaining at Gatun.

There are several places, therefore, where the Chagres bed has scoured fifty to sixty ft. below sea level. A specific fifty-foot pool is particularly noted which existed 2,000 ft. below the site of the dam. If the uppermost pervious stratum found now at Gatun is continuous for only such a short distance farther, as to this deep scour, there is therefore provided a subterranean conduit here at once 20 ft. in face and of unknown width. The bearing of this pool and the opening into it of the pervious stratum from under the Gatun Dam will become evident presently. The other factors of the situation must be marshaled first.

The Gatun Dam is a huge embankment. It is designed to impound the surface run-off of the Chagres Valley—that is, about 53% of the rainfall. No masonry barring curtain can be carried here to the bedrock far below the limit of pneumatic caisson work. Human endurance and working power under compressed air is limited to about 100 ft. underground in the temperate zones. It is probably less in the tropics, where very little of this kind of work has ever been done. Grouting was undertaken to stop leakage at the dam below Cairo, in Egypt, but it was only to a limit successful. The author of the method, our friend of the years, the late Mr. Kinipple, M. I. C. E., defined its limitations.

Grouting has been, by the designer of this Dam, suggested for Gatun. The Gorges (in the conjectures based upon the seven borings in half a mile, 2,650 ft.) are taken to have an area of 370,000 sq. ft. It is said 150,000 sq. ft. of this can be cut off by sheeting, which would leave 220,000 sq. ft. in a zone from 154 to 218 ft. deep, under a stratum 50 ft. thick, to be made water tight by grouting. 220,000 sq. ft. would be the section of a river over four miles wide and ten ft. deep. Is grouting to be seriously considered for this situation?

It is manifest that no methods at all practicable, under the conditions in these gorges, exist for cutting off the underground flow under the dam. This must remain in the Government project.

Geikie's warning against constructing embankments over such subterranean conditions as exist here quite aside from artesian features has been given. Dana's suggestion of consequences is added:

"A clayey layer overlaid by other horizontal strata some-

times becomes so softened by water from springs or rains, that the superincumbent mass, by its weight alone, presses it out laterally, provided its escape is possible, and, sinking down, takes its place.

"Near Tivoli, on the Hudson river, a subsidence of this kind took place in April, 1862. This land sunk down perpendicularly, leaving a straight wall around the sunken area 60 or 80 ft. in height. An equal area of clay was forced out laterally underneath the shore of the river, forming a point about an eighth of a mile in circuit, projecting into the cove. Part of the surface remained as level as before, with the trees all standing. Three days afterward the slide extended, partially breaking up the surface of the region, which had previously subsided, and making it appear as if an earthquake had passed. The whole area measured three or four acres."

The Gatun dam, because of its enormous mass, would be next liable to the breaches incident to uneven settling, even were the special water conditions absent. This was the line of opposition brought out by the majority.

At Gatun, "vulcanism has long been inactive. These old volcanic ejecta have been sorted out by the action of the water into sheets of sediment, which have been compressed and wrinkled into most complicated mountain folds, through the stresses which the earth's crust has been undergoing."

The unequal settlement which might result from the variable character of these foundations at Gatun was efficiently discussed. The special danger at the two points where the dam, leaving the clay foundation of the hills, twice crosses the softer materials of the Gorges was pointed out. These were regarded as special foci for breach. A breach would start scour, and of course the whole dam might be eaten out speedily. The greater the height and weight of the dam the more likely is this to take place. The less the height the less the likelihood of uneven settlement and the resultant cracks.

The conditions under the Wachusetts dam in Massachusetts are not at all those prevailing at Gatun. There the permeable strata were most carefully cut off.

A dam itself is readily made practically impermeable. A dam of earthfill or arch construction with an impermeable face conjoined with an immovable mass—immovable by virtue of weight or shape—is, under right foundation conditions,

a perfect dam. Rock and earthfill dams have been very successfully built and maintained in alluvial valleys, but this does not mean that they can be successfully built to any height and magnitude in every alluvial valley, or with permeable and artesian strata under them. The specific local factors and conditions must be known and regarded. Geikie goes on record emphatically here:

"The selection of a site for his embankment demands from the engineer the greatest care. Sometimes there is no difficulty—the bed of the valley may be deeply filled with tough homogeneous clay, than which no better foundation could be obtained. It is always well, however, to make sure by a series of borings that no water-bearing beds are present or underneath the clay, for in either case these would be a source of danger—allowing of leakage, and thus threatening the stability of the embankment."

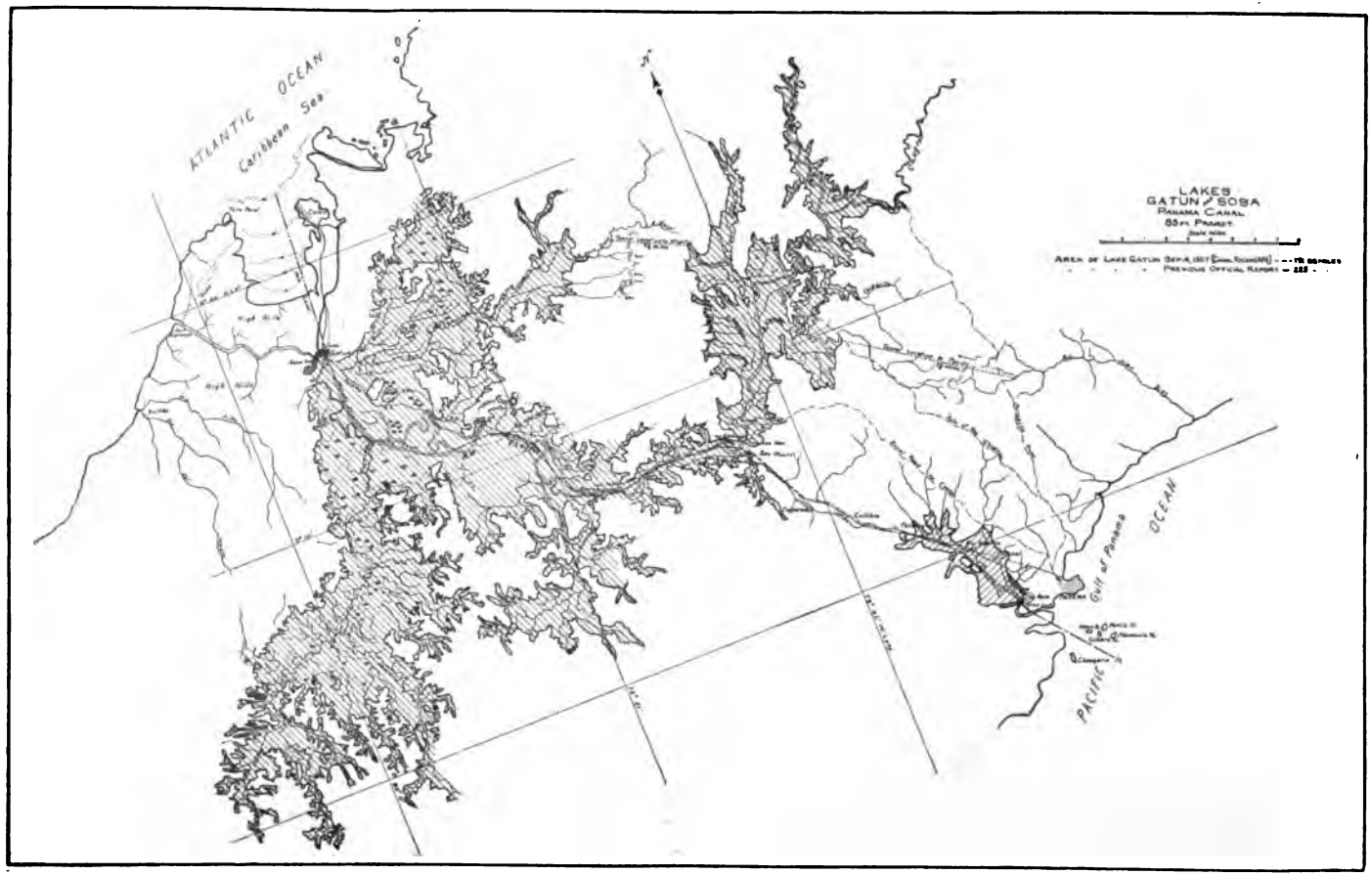
It is not here intended to imply that the artesian uprisings would forthwith begin eating out the under stratum. No one can at all forecast where artesian water under pressure shall issue, or at what head. The artesian feature is not either in the writer's judgment a needed contention for condemning the foundations here. The great water-bearing strata which the borings have revealed are in themselves, quite aside from artesian quality, sufficient to make unsafe this high and heavy construction.

CHAPTER X.

85-ft. Gatun Lake.

We turn now to the most consequential feature of the Gatun situation. This is the 85-ft. lake. The dam has of itself no saving effect upon the great area of underground drainage or the conditions creating artesian flow. Its weight has no material effect in diminishing the reach of the vast supplying conduit system. Such a hope would be too futile to be given serious consideration. But the head and amount of water to be impounded behind the dam has a vast importance to the Canal, because it must create a wholly new situation. A lake 171 square miles in area will be dammed back to a height of 85 feet. Its long, irregular shore line must be very extended, reaching more than 100 miles. At or near its borders it will inevitably be in contact with and cover the thousands upon thousands of small inlets to the underground conduits from small ravines—the conduits leading to the great gorges of the subterranenan Chagres Valley. The lake itself, 85 ft. high, much of whose bed is at present swamp, will press here permanently upon the permeable soils, muck, sandy clay, etc., underneath which lie again these open mouths. They will be fed then under a supply and pressure which are vastly beyond anything obtaining before. The hydrostatic pressure under the dam will be very greatly raised, and will become much more menacing than that now existing. On the other hand, the frictional resistance will be very much diminished, because the conduits will be, in effect, just so much shortened. If after the dam is built a boring were put down below it, the height of artesian discharge would necessarily be found to have been greatly increased. The height would certainly not be the 17 ft. now obtaining; it would be, from hydrostatic law, upward toward the height of the lake, 85 ft.

The Gatun Gap is the only outlet of the 133 sq. miles of lake below Bohio and the 500 sq. miles of the watershed of the Gatun and Trinidad rivers. On this watershed area there is, besides the lake, an annual rainfall of 137.67 ins., roundly 138. At Bohio in 1898 it was 204.61 ins., or 17 ft., and in August of that year the precipitation was 38.01 ins., or 3 2-10 ft. At Colon in 1862 the rainfall totaled 43 inches in


ATLANTIC OCEAN
Caribbean Sea
PACIFIC OCEAN
Gulf of Panama
LAKES
GATUN & SOSA
PANAMA CANAL
85 FT. PRIMET

the month of November. In the very wet years, therefore, 138 ins.—11½ ft.—is exceeded by probably 50% in these areas. Besides, there is the great contribution of the 880 sq. miles of watershed above Bohio.

Of all this the lake is to be a gigantic reservoir with 171 sq. miles of bottom dipping and leading to the geological gorges of Gatun. It is further an unlined and unlinable reservoir.

There will be certainly a great reduction of friction, because the lake with its vast supply to the subterranean pipes has been brought right at hand. As earth friction is reduced, the artesian delivery fountain rises, as was said.

The surface clay at Gatun is but 31 ft. thick. It blankets the uppermost permeable stratum, a fine sand, saturated like quicksand. Above the dam there will be a pressure of 40 lbs. on each sq. in. from the lake.

The weight of the Gatun Dam distributed over the area which it covers cannot close the voids between the particles of sand, gravel, etc., in the two gorges 204 and 268 ft. below. Its weight will but act to bring an increased pressure on the water-bearing strata. These strata are already water-logged and lie in and under the debris mass which fills the gorges to nearly twice the height of the dam. We quote Dana again:

"The height may be that of the neighboring hills or of distant mountains, according to the range of the sloping rock layers along which the water descends. It may be that of the lakes, small or large, for these bodies of water have the double duty of supplying above ground and underground streams. While the hydrostatic pressure varies with the height of the water supply, the extent of the region served by a single source will depend on the area of that source.

"Professor Edward Orton of Columbus, Ohio, has proved that the hydrostatic pressure in the Findlay Oil region and also in Indiana, where the borings descend to the Trenton limestone, reaching at various depths to 1,000 ft. or more below the surface, is determined by the waters of Lake Superior. The level of the lake is 600 feet above tide level; and by adding this height to the number of feet at which the Trenton lies, in any case, below tide level, and calculating the hydrostatic pressure on this basis, he has found

that it corresponds closely with the actual gas pressure at each boring. He holds that this hydrostatic pressure determines the gas pressure in other regions. The fact exhibits on a grand scale the influence of a large elevated lake on the conditions of subterranean pressure."

"Subterranean waters do much efficient work by transportation of sand along the course of streamlets," Dana continues. Suppose the under sands start to move, a most possible supposition surely, under the new superimposed lake Gatun.

Let them start running into the Chagres at a flood time, when the spillway is handling 140,000 cu. ft. per second and the Lower Chagres is coursing a dozen miles an hour. The velocity is sufficient to move immense quantities of sand and silt to the sea. How safe, then, is this Gatun Dam?

Or under the superimposed hydrostatic pressure let an artesian spring begin action at the 50-ft. pool in the river, how safe, then, is this Gatun Dam? Or, aside from artesian flow recall the 20-ft. open face to the first permeable layer under the dam if it reaches the pool. Let but the normal pressure of the lake start activity here and the carrying down of the sand. How long will be needed to scour out a subterranean channel, start the Chagres bed to caving, undermine the foundations. How safe, then, is this Gatun Dam? Here are effective agencies surely for bringing to sudden termination the history of the Panama Canal.

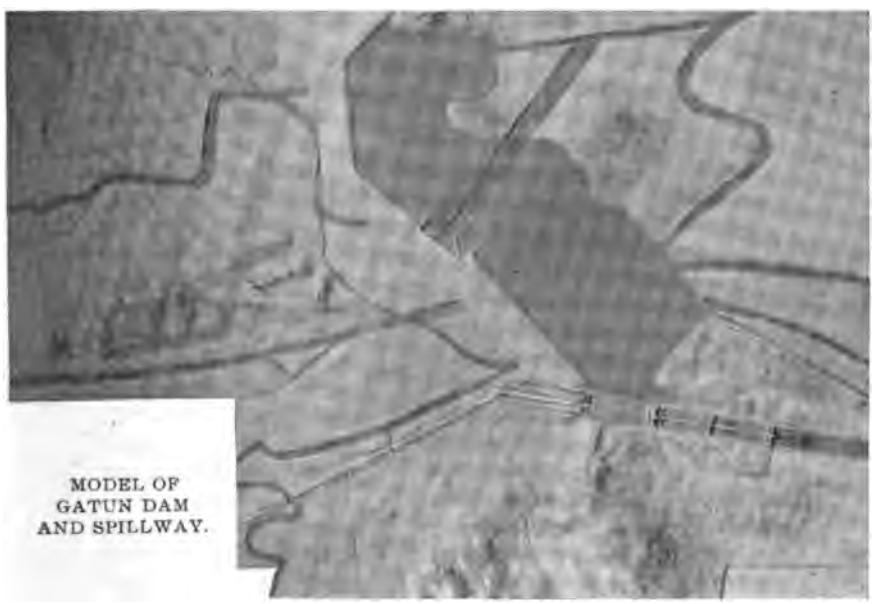
In summary: The great height and mass and weight of the Gatun Dam make it especially dependent for safety upon adequate foundations. Here no rock is obtainable; the foundation must be alluvial. Two deep gorges lie beneath containing porous and permeable materials. This porous material, being more readily compressed than the clay of the hill, uneven settlement can follow. Water-soaked strata exist at varying depths between 31 and 268 ft. There are artesian conditions. An 85-ft. lake is to be impounded, bringing additional hydrostatic pressures upon the subterranean flow. A river pool below focuses special opportunities for underground run.

In the survey of all existing hazards, is the Panama Canal to intrust its very existence to the Gatun Dam projected for it? The late chief engineer of the new Croton Dam, read before the meeting of the American Water Works Associ-

ation in 1902 a paper of interest. He collected brief histories of fifty-one dams and reservoirs, and reported forty-eight others in our own country which have failed within recent years.

GATUN SPILLWAY.

We have considered the factors and conditions of the Chagres and its bed below the Monster Dam. The Chagres had gouged immediately below, the deepest pool in all its coursing to the sea—a pool fraught with much meaning to the geology of the valley and part of a condition of ruling significance which will appear.



MODEL OF GATUN DAM AND SPILLWAY.

The Pool as surveyed was some 2,000 ft. long and varied from 40 to 50 ft. in depth, when the Chagres went down its main channel to the sea before part of it took a short cut to Limon Bay through the French Canal. The bed of the pool was about 300 ft. wide. This reach now, probably partially filled with sludge unless gouged out by the late floods, parallels the foot of the dam.

The Gatun Spillway as planned debouches directly into this charted hole. In the concrete of the Spillway, the distance between walls on Plate XII. (Report of Minority) is given as 790 ft. at the lake level, and the crest is 70 ft. above the sea. In this place are set the Stoney gates.

The water is to rush down a converging toboggan with a head of 16 ft. over a crest of 70 ft. above the normal river surface below. There is to be, therefore, a fall of 70 ft. between the crest and the level of the river in the channel, which it is proposed to excavate to connect the Spillway and the river. This amount of fall takes place in 287½ ft., and the concrete channel extends 80 ft. beyond the foot of the slide. The concrete incline narrows from 790 to 160 ft. bottom width, in the drop.

It is noted first that the gates are designed to pass 140,000 cu. ft. per second. That is the exact amount which is computed in all the records (and the designs and estimates are based upon them) to have passed Bohio, ten miles up the river, in the great flood of 1879. That flood was nearly paralleled in November, 1906. Past Gatun the total was not 140,000 c. f. s.; the volume was necessarily swelled by the flood from the watershed between Bohio and Gatun, which has been computed to add 77% more, making a possible total of 247,800 c. f. s.

In the Government Canal a high level is adopted of 85 ft., sustained by a single dam. It follows that there must be a valve to regulate the level of the lake, i. e., release the flood waters of the Chagres. This Spillway is made to the full width of Spillway Hill, 790 ft. in the clear, with a number of gates, each 30 ft. wide and separated by piers. They total some 600 ft. of opening.

A large increase, indeed a veritable doubling of discharge capacity is desirable in the Spillway in order to have a factor of safety having respect to the great 500 sq. mile watershed below Bohio, which was disregarded. Certainly, if one accepts the dictum that a Spillway at Bohio equal to passing 140,000 c. f. s. was prudent, as the Commission of 1901 decided, it would be no less necessary to provide for 247,800 c. f. s. at Gatun. Although Gatun Lake is several times as large as the Bohio Lake, 171 sq. miles, as against 38, it is in a rain belt, one of whose points has at least 200 ins. per annum sometimes, or double that of the water-

shed above Bohio. In the tropics one never knows how much it can rain in twenty-four hours, but one foot is not the limit. The writer knows of a tropic storm in Queensland, when nearly three feet fell on the slopes of the Brisbane River Valley in a day and a night.

Floods will be reflected quicker than ever in this lake, because the distance which the water has to travel from the hills is shortened. Also, it is quite sure that the amount of water getting into the ground already saturated will be in percentage less than has been heretofore allowed where there was no lake. It would be prudent to reckon the run off at 75% instead of 50%. These considerations emphasize the need of having a much larger factor of safety in the capacity of the Spillway provided. This is a matter that the Minority should have computed and rightly arranged for instead of moving the Bohio-Gigante Spillway provision bodily to Gatun.

A Spillway is indispensable. It becomes really the way, the substitute way, of the swollen Chagres to the sea. It involves a study of the hydrology of the Isthmus, its rainfall, its run-off, its evaporation, its underground condition and flow, its flood and drought, its lockage supply and many allied questions. The chief of these from a Canal standpoint are embraced in the phrase—

"THE REGULATION OF THE CHAGRES."

There are three principal ways to regulate the Chagres:

First.—By a lake constituting the summit navigable level of the Canal and spilling into the Atlantic alone. This is the 85-ft. lake system.

Second.—By a series of permanent lakes off the course of navigation. One of these would be on the Chagres above Gamboa, two would be in the outlets of the Western watersheds, between Bohio and Obispo. The lakes would discharge by regulating gates into the canal prism and diversions of the Chagres on either side. The Canal water would be arranged to run to both Oceans. This was the Bates new divided river system of 1905, and the Sea Level abandoning its tunnel scheme incorporated it for the solution of the Chagres.

Third.—This combines navigable summit lake regulation, the division of the stream, and the normally-empty basin

system. The three regulating dams would be set at Gamboa and above, and on the Cano. A division would be made of the flow, which would go not to one alone, but to both oceans, through the navigated channel. There would be normally empty basins above the dams.

The last is a perfecting of the first method. The Summit Lake, can, under it, be lowered to 60 ft. or 30 ft., or even less and still possess the invaluable factor of Chagres regulation by a navigable lake. Normally-empty basins are ready for a flood and make the maintenance of the navigated levels simple and secure. The third has all the safety factors of the other two and neither of the others has anything like its security and preparedness to meet the most adverse conditions of rainfall and rapidity of run off. Under it low dams of small volume can be used at the Isthmus and all the dangers of the massive high structures, high head lakes and locks flights can be avoided.

The last two combinations were, so far as known, never proposed till the writer set them before the Government. These principles of regulation were incorporated into both the Sea Level scheme and the 60-ft. three-lake Canal design, which the majority pronounced the best lock canal.

Egress and discharge are essential to summit lake regulation. Since there is but one outlet to the 85-ft. lake it must be prudently designed and of very sufficing capacity. The regulating system "three" provided for 50,000 cu. ft. a second to go to the Pacific, 140,000 to the Atlantic, and 110,000 to be impounded in the upper Chagres and Cano—a total of 300,000 cu. ft. a second, besides affording the reservoir of a lake.

The Minority has a lake but little larger, and it provides for a flood flow of less than half that accommodated under system "three." Under the Government scheme, with a certain capacity imperative, the Spillway site becomes most important. At Gatun the Commission put their Spillway midway the dam. The hill containing the concrete works and mechanism may be adequate. They report suitable foundations, and one would naturally expect them in such a hill—though the Spillway was located, designed and estimated without a boring.

The Spillway cannot come into action until the lake has collected 70 ft. above the sea or to within 15 ft. of its

ultimate level—85. In short, no water can escape until the lake is nearly full, until both sections of the great dam containing 21,200,000 cu. yds. of earth and rock are completed. The problem then becomes, since there are only 90 days in the year immune from floods, that of closing one section and keeping the unfinished embankment safe from overtopping by sudden rises. There will be here inevitably, grave construction risks.

Assuming, however, their success, the serious test is certainly to come when some great storm blows in from the Caribbean Sea with its incident deluge. It may well be that for twenty-four hours the gates will be obliged to pass the maximum discharge, for it will not be desirable to let the lake rise over a foot, if this can be at all avoided. Floods are rarely realized until they are on. Then there will be the fullest Chagres torrents rushing through the gates into a channel rapidly narrowing from 790 ft. to 160 ft. and plunging down the slide of 70 ft. into a shallow earthen trough. It will be recalled that the maximum flood discharge is approximately 247,800 cu. ft. a second past Gatun. Assume only 140,000 cu. ft. a second for which alone the Minority have computed and provided. Let 140,000 cubic feet a second go over the Spillway crest, through the gates and down the 70-ft. toboggan shute into the Spillway channel and thence to the Pool.

If in the converging throat, near the foot of the shute, the stream is 20 ft. deep, it must have a velocity of 44 ft. per second, or 30 miles per hour, in order that the 140,000 c. f. s. shall get away. A rush into the old Chagres bed at high velocity would quickly begin eroding the pool. It was 50 to 60 ft. deep. It would almost surely be deeper than ever. The Missouri at a concave has been known to scour 100 ft. below its bed, at only six miles an hour. The heaped-up center of this Spillway escape will be going very fast. Suppose the outlet end of the Spillway channel be eaten down during a flood—soft rock is eroded by high velocities all too easily—where will the back cutting end? Again, where do the two geologic gorges unite below the dam? Do the engineers of the Commission know? Do they care? This has never been explored by Commissions American or French. Do they unite? Where do they go? Doubtless they extend to the pool. Suppose this tor-

rent—it is nothing else—cuts the permeable strata of the West gorge and unseals the dam? Will it do it? It could surely. It runs across its strike.

And what if, to hold the lake to the navigating level, the whole Chagres flood of 247,800 cu. ft. a second has to be let through the sluices which they will not accommodate; or even some added part of the flood waters as this lake rises despite the wide open gates? From the sluices, the water comes via the converging slide to the plunge into the Spillway channel through the marsh and into the eddy-whirling Pool. Are these conditions promising to safety? It looks as if another geologic gorge might be scoured out in short order, cut back and sever the dam, especially if the converging feature is retained, and the horizontal whirlpool at the throat now planned be conserved. Is the Gatun Dam to be let suicide in some great deluge? Spillways lose their dangers as the head of water on the dam diminishes. Let the Gatun Dam have on its upper side, say a 60-ft. level and on the lower a 30-ft. lake. Let tobogganing be eliminated in the discharge design and the water passing double or triple the number of gates be rendered by the lower lake and the wider spread quite destitute of erosive power. There need be no digging of canyons—no back cutting, no danger. Not only so, but the Spillway, or undersluice barrage can then occupy the section next the Western range and be quite separated from the main dam by the width of Spillway Hill. It may be of masonry like the Assuan Dam, and founded on indurated clay rock, yet subjected only to the head on the Assiut Barrage across the silt bed of the Nile. Or better yet the Spillway may be in the saddle of the Trinidad Range west of the dam and recently surveyed and found to be but 86 feet above sea level.

The utter indifference to real information as to existing conditions at Panama has been astounding. Despite, for instance, the private knowledge of the Commission of 1906 through their last fifteen months that the bores in these Gatun gorges were flowing bores, not one additional test had been undertaken in them.

The writer has recorded that there is evidence of a later uplift between Gatun and the sea. There are some interesting and authoritative and ruling data in existence which have never received from any one else the slightest consideration

in their relation to Isthmian Canal projects. The United States Commissions have brought not one new contribution to these waterway designs. The International experts called from many lands have but beaten the old chaff, save where they have purloined.

In summary of the foundation conditions one thing is certain. First and foremost and indispensably there must be at the Isthmus, since the underground conditions have been revealed, the safe barring-off of permeable strata under the crucial dam. This cannot be done at Gatun for the hign dam. Nature has done something elsewhere. She has made possible one eminently feasible and safe design.

CHAPTER XI.

Dam and Lock Sites North of Gatun.

Reefs Across Chagres River.

We gather the factors. To minimize the Culebra mass to be dug, and to regulate the Chagres, a lake summit-level 85 ft. above the sea was adopted. The higher the summit lake-level the less the Culebra cut. But too high a lake-level entails several other things much worse than digging even this mountain.

The Chagres can be regulated by a lake down to 60 ft., or even 30 ft., and assurance can be made doubly safe by under-sluice dams of the Assuan type at both Gamboa and Alhajuela. So the choice of an 85-ft. lake was not in any degree whatsoever compulsory from a technical standpoint.

Next the Minority and Commission and Secretary of War passed over the lock and dam sites below Gatun. They did not even seriously examine them or try to gather the data to prove or credit their suitability. Yet these sites held all the possibilities of making a safe, low-leveled, low-dammed, separate single-locked canal at Panama. They recognized the need for an adequate lock supply. They knew that two locks of 42½ foot lift in flight at Gatun would take one-third more water than three locks of 28½ foot lift to pass a ship. Hence they made a flight of three. They have, therefore, a design with the Mountain Dam upon the foundations that we have been considering and the lock flights of general condemnation—and both needless, utterly.

Our analysis has shown that in the Gatun Gap there is first a surface river running at an average of 8,500 cu. ft. per second through channels of relatively small section; second, underground water, flowing very slowly but steadily, which finally gets to the sea, through the permeable strata of two geological gorges at Gatun. These two gorges are one at Bohio. They go no one knows where, for a surety, below Gatun; third, the water-bearing strata are artesian and are under hydrostatic pressure from the upper reaches of the river, the tributaries and ravines. The artesian plane at Gatun is about 17 ft. above the surface of the river, which is practically sea level at low water; fourth, there is no geologic gorge at Mindi; and fifth, the channel of the Chagres

below Gatun was formerly very deep—upward of 58½ ft. in places, before the French Canal was dug.

It has been seen that it is unsafe and a courting of disaster to put a dam under an 85-ft. head over deep gorges filled with a jumble of permeable and impervious strata. Especially as they hold an underground river and the clay cappings over the buried river are in a state of artesian stress which must be augmented by the lake, that is to cover the upper ends of the underground conduits—along literally scores and scores of miles of its coast line.

Now what is to be done? If there is no way by a bedrock curtain to cut off this steady underground water movement under the high Gatun Dam, what follows? There is no artificial way to prevent the artesian stresses. If then, there is absolutely nothing that can be done for safeguarding, the right and rational procedure is to condemn and to abandon the high dam, high head, high lake, six lock, 85-ft. project, and if any other design exists which satisfies all the conditions of navigation; all the conditions technical, and all the conditions financial, to substitute this Canal instead. Is there any Lock Canal which incorporates safe dams? This is the first question. Safe dams must be manifestly upon Isthmian foundations low dams. Low dams prohibit lock flights, so a low dam canal will be a canal of single, separated locks. It would bring therefore at once the two leading canal features supremely desirable if such a design could be secured.

To incorporate low dams into a four lock canal one must have three lakes—one between Mindi and Gatun, one between Gatun and Gamboa, one between Pedro Miguel and La Boca. To incorporate low dams into a two lock canal there would be two lakes, one from Mindi or Gatun to Tavernilla and one from Pedro Miguel to La Boca.

There is at Panama a level whereat a two lock canal is as cheap as a four lock canal—where the extra cost of building two locks and their incident dams and regulating works becomes equal to the cost of the extra excavation involved at Culebra and elsewhere in adopting the lower plane. Both the two lock and four lock plans are cheaper and far easier to execute than the Government's six lock canal. This level, at which a two lock plan costs about the same as a four lock, is susceptible of accurate determination. The

alternative to the high Gatun Dam system is the low dam system, and this involves fundamentally the question of sites. If the heights and heads are to be reduced on the Panama Canal to any safe limit one site becomes of pre-eminent importance—Mindi. The first dam in a right waterway must go in at Mindi. Fortunately the rock is close to the surface.

Having rock foundations, the Mindi dam is lifted out of the realm of the hazardous and becomes secure. Next a dam must be set on the Lower Chagres. Before the Bates Lake Canal Project evolved its dispositions no attention whatever had been paid to the Lower Chagres for half a century, either as a canal route or as a section where dam sites having any bearing upon a lock canal could exist.

It has been impossible to engage for it yet, serious concern, let alone co-operation. It has been first merely novel, then disturbing that any one should persistently advocate a dam on the Lower Chagres. Every one has assumed that the geologic gorges of Bohio and Gatun become deeper and deeper to the sea. Every Commission and every official took it that because there was no site for a masonry dam or masonry curtains to bedrock at Bohio and Gatun—that ended the story. There were to them no other possibilities, no alternatives.

The amount of official exploration during 1906 is represented by the following:

The Isthmian report of 1906 devoted thirteen lines to the work done in the Gatun section, which is the crucial division of the whole 85-ft. six-lock canal. In it are placed the mountainous Gatun Dam, the staircase of locks and the safety device to hold Lake Gatun in event of disaster to the lock gates. The chairman does not even refer to the subject in his "Report." The chief engineer's thirteen lines read as follows:

"The work on the Gatun section has been confined to surveys and the borings of the test holes to determine the character of the material along the canal and in the vicinity of the proposed lock and dam at Gatun. Surveys of the main line of the old canal, with borings, were made between Gatun and Bohio and also north of Gatun.

"Topographical surveys have been made in the vicinity of the proposed lock and dam and additional surveys made

between Gatun and Mindi. Thirty-six test holes were put down along the axis of the dam, having a total depth ot 25,000 ft., the deepest being 265 ft. below the surface. One hundred and eight holes, having a depth of 9,000 ft., were put down at the location of the proposed lock, about sixty of them having extended to a depth of 60 ft. below sea level. Thirty-two holes were put down on the site of the proposed spillway."

The two lines following are, in addition to the above, all that is vouchsafed in regard to the explorations of the topography in the vicinity of this momentous work, and these lines are looking toward another spillway site.

"Thirty-six test holes," the chief engineer's official report says, "having a total depth of 25,000 feet, were sunk." This will give an average depth per hole of 694.4 ft. But the next clause reads "the deepest being 265 ft." It is not to be supposed that 429 ft. on each test boring was in the atmosphere, so we must conclude that the statement is somewhat erroneous.

Under date of January 12, 1907, the Chief Engineer cables of the dam borings:

"Pervious material in only four holes and those below 200 feet."

This is precisely the Chief Engineer's testimony before the Senate Committee last winter. It was correctd by Professor Burr, and the Maltby Boring Map of November 3, 1905, was adduced as proof positive of the "mistake" or misinformation. In January, 1907, the same "error" reappears for obvious reasons of consistency. The facts of the borings are not altered and their record might wisely be avowed, for the Senate confirmed them in the testimony of four witnesss who, being of the Board, had the Maltby field notes.

There have been few additional explorations in the valley. There is no telling yet where the two geological gorges of Gatun unite, whether below or above, or what are their depths or widths underneath the dam. It is more than possible that Spillway Hill is on the verge of a cross gorge, connecting those on either flank. Certainly some knowledge of these factors might be advisable to a high dam. The Isthmus is very old. We quote the following note made by Mr. R. C. Smith, who made the 1901 borings at Bohio:

"Deep underneath the surface, and extending from the

upper to the lower limits of the section examined, was found an old buried rock channel 300 to 500 ft. in width. The limits of this channel are shown on the map in dotted lines; its course does not follow that of the present bed of the river, but crosses underneath it at the lower end of the territory examined, again in the vicinity of the French dam site, and comes back to the right bank of the river at the upper end of the section examined. Overlying the rock in this channel a bed of permeable sand and gravel 40 to 80 ft. in thickness is found. Above this material and extending to the yellow clay are alternating layers of blue clay and sand, and clear sand, the sand layers usually less than a foot (although occasionally as much as three or four feet) in thickness and always permeable. These strata are not continuous from hole to hole—in fact, they might better be described as pockets of clay or sand instead of layers. It is probable that these permeable pockets are connected one with the other, and ultimately with the bed of the river, which accounts for the sudden loss of flow from the (force) pump the instant a sand pocket is encountered. Within the limits of this old channel, every hole drilled showed a large amount of permeable material, while outside these limits many of the holes were water tight from the surface to the rock. Others show occasional beds of sand or gravel, though not very thick, and not at an elevation of more than 75 ft. below sea level."

There are three hills which overlook the Lower Chagres, Mindi and Gatun situation. Standing on Locksite Hill at Gatun, looking west two miles, one sees the summit of "Cerro Gatun." Locksite Hill is not the true Gatun Hill, but this Western one—on which was once a trigonometric station of the first accurate survey of the Panama Route in 1843.

Two miles or so to the north of Locksite Hill is Jaramillo Hill. "This is the first hill on the right that we saw when we went down the Chagres river," the engineer writes to remind the members of the Advisory Board who steamed down from Gatun to the sea in a blinding rain and saw almost nothing.

Jaramillo Hill is 375 ft. high. Cerro Gatun is still higher. These hills overlook the "Marais de Torna Sable"—a marshy tract between Gatun and the Bay and west of the French Canal.

"Marais de Torna Sable" means the "Swamp of Quicksands."

At a point about three-quarters of a mile northwest by north of the old Engineers' Headquarters at Gatun, and beyond a quick westerly bend of the Chagres, a large slough is encountered. One branch of it runs straight to Jaramillo Hill on the strike of the Eastern Gorge and parallel to the French Canal. Another branch runs westerly, parallel with the Chagres. A quebrada, or creek, runs from the south foot of Jaramillo Hill into the Chagres at the northern lower end of the swamp. The western slough is a blind one, too.

Both slough branches are clearly defined, but begin nowhere and end nowhere. They are apparently the surviving evidence of a past geologic condition—when the channel of the river was different from what it now is. There is such another slough south of La Bruja above Gatun.

There is an official report of special value to this discussion, made with unusual ability and fidelity. It is of the supremest value to the right lock canal of Panama. We quote some passages: "The shores of the Atlantic offer different characteristics. The sandy beach which forms to a great extent the shore of the Isthmus stops at the mouth of the Chagres river. Between this point and Limon Bay, situated five miles to the northeast, the cliff is somewhat pronounced, and is formed into certain projections by escarpments 200 to 260 ft. high. It is on one of these rock plateaus forming one of the sides of the Chagres Port that Fort San Lorenzo is built. The nature of the rock here is rather easy to observe. It is an alternate of fine sandstone and of calcareous shell melange, pertaining evidently to the tertiary period. In the most of these rocks one finds near Limon Bay, banks of coral, which farther to the east, at Porto Bello, are much more abundant and were anciently employed as building stone. The same formations characterize all the country situated between the Chagres river and Limon Bay, and it seems to extend in mounting the river to beyond the Rio Trinidad.

"In ascending the Chagres river above this point one meets almost constantly raised bluffs, formed by very clayey ground which covers the rocks. In almost all these points, where they are bare, they are but conglomerates of a formation evidently recent, composed of granite cores, porphyries,

etc., proving them to be the rocks of ancient formation which constitutes the mountains of the center of the Isthmus. These nuclei altogether resemble the rounded pebbles which one meets in the higher parts of the Chagres river. These nuclei are agglomerated into a paste of friable sandstone, or rather an agglutinated sand, without much consistency, and of a gray or green color. These rocks are not found again till one goes away from the river, a circumstance which clearly proves that it is to these waters that is due the transportation of the parts of this species of conglomerate, as well as the formation of the arenaceous rock which impastes them. There is, then, here a formation altogether distinct and separate from the rocks constituting the terrains of the Isthmus, with which it has no connection save by the borrowing of the same constituent principles.

"Meanwhile, one finds again at two points rock well stratified visible in place and forming part of those which compose the soils of the Isthmus.

"Above Vamos-Vamos, between this point and the Estero Juan Gallequa, on the right bank, one meets white rocks of calcareous sandstone and of grained calcareous substance traversed by crystalline calcareous veins in beds of more than 3¼ ft. thick, directed from the southeast to the northwest, dipping around 20° toward the southwest. With these calcareous beds are associated those of a fine grayish sandstone, in which one finds disseminated here and there certain particles of crystalline limestone.

"Both of these rocks, and particularly the first, seem to me to have been very well able to have served as building stone. As for their geologic age, the small reaches over which they are visible, the impossibility of recognizing their direct relation to the other terrains render their exact determination quite difficut. In the meantime, their mineralogic character, their association, and their position intermediary between the tertiary rocks of the lower Chagres and the more ancient rocks of the Central Mountains brings me to place them toward the middle of the secondary period.

"In giving a resumé of the preceding observations one is brought to admit at the Isthmus four quite distinct formations." Of these the fourth is, "finally, formation of sandstone and tertiary limestone with shells, the most considerable next to that of the trap and the porphyry, and which

comprehend all the formation *which extends between Trinidad and the sea, on the left bank of the Chagres and on the right bank, all this which extends as far as Limon Bay.*

"The trap rocks and the porphyries are here associated as they generally are in other countries where they have been observed. One of the exterior characteristics of the soils composed of these rocks is to take on the form of rounded mamelons or of conic buttes. This, their characteristic, is found on the Isthmus. The masses of the mountains present rounded contours except certain isolated conic mountains."

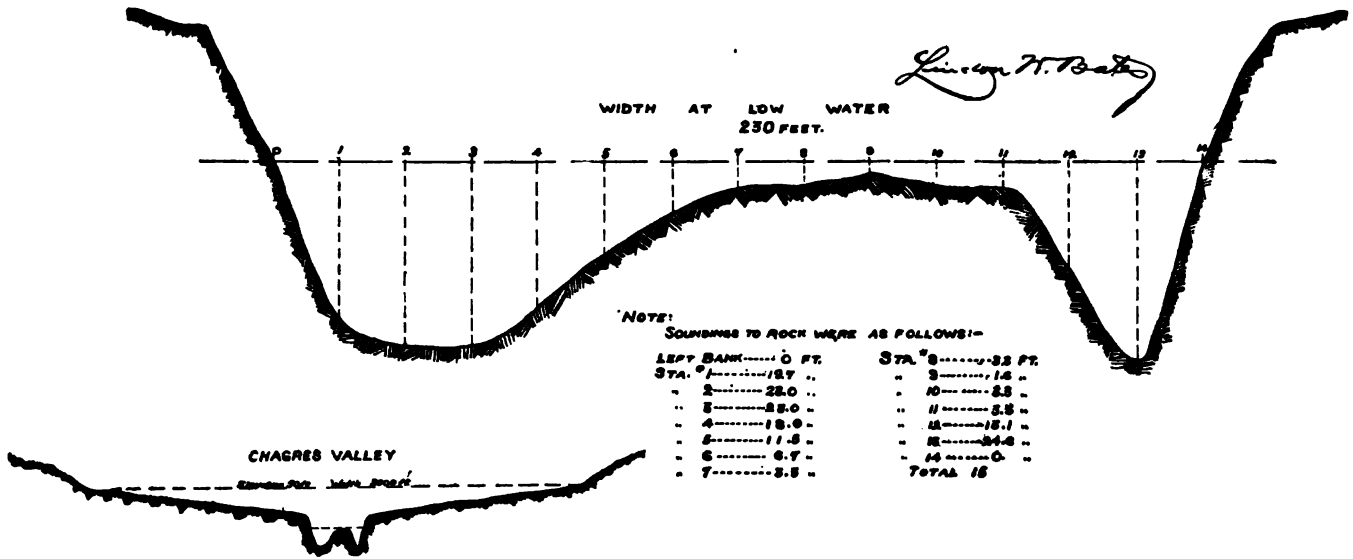
The relation of this Lower Chagres geology to the Canal situation is of the profoundest importance. It is now detailed in connection with Canal plans.

The writer has been minded before to set it forth, but doves sent out formerly from his ark were found in strange company and it was not expedient. We quote further:

"The accompanying maps of the Isthmus have been made by means of a trigometric triangulation, starting from a suitable base measured on the eastern beach of Panama. The angles of the triangles of this train were measured with a theodolite, repeating each angle at least five times. This train of triangles taking in the Island of the Road of Panama, was prolonged from Panama to Cerro Gatun—the extreme point toward the northeast, which we have tied to an exact plan of the Chagres by means of three stations taken on the river. This last plan has been made from the mouth of the river up to Dos Hermanos (4 miles above Gatun at the mouth of the Trinidad), a distance of about 19 miles. In this last work I was assisted by a boat from the brig-of-war Le Papillon, commanded by M. de Sainville. I used for this survey a 'bearing' compass and a line of linked chain sustained by floats."

These surveys record the master factor in the Canal situation, the most important on the Isthmus.

THERE IS A ROCK REEF OF "LAJA," A LAVA-LIKE LEDGE EXTENDING RIGHT ACROSS THE PRESENT BED OF THE CHAGRES RIVER, BETWEEN GATUN AND THE SEA. The reef runs northeast and southwest on a line connecting spurs of high hills. The accompanying plan, taken from the official profile and survey notes, shows the actual cross sections of the river bed at the reef. The Chagres



NOTE:
SOUNDINGS TO ROCK WERE AS FOLLOWS:—

LEFT BANK	0 FT.	STA. 8	3.3 FT.
STA. 1	12.7 "	" 9	1.6 "
" 2	28.0 "	" 10	2.3 "
" 3	23.0 "	" 11	3.3 "
" 4	18.9 "	" 12	15.1 "
" 5	11.5 "	" 13	24.6 "
" 6	6.7 "	" 14	0. "
" 7	3.5 "	TOTAL	15

PROFILE OF ROCK-REEF ACROSS THE CHAGRES RIVER.

at this point is 230 ft. wide, the valley about half a mile only. There are two channels across the reef—the greatest depth in the right channel is 24.4 ft.; in the left and wider channel it is 22.8 ft. The channels were separated by rock, coming to within 20 ins., of the low water surface in the right center of the stream.

Below the reef the water is shallow for some 4,300 ft., carrying about 26 ft.—then there is again a pool over 42 ft. deep. Between this and the river mouth there is a succession of four bars and their accompanying pools.

One pool (above the Rio Indio) is 58½ ft. deep, and a little distance below there is 22¾ ft. of water. There is yet another shallow stretch carrying 21 ft. of water. These great variations of depth are not found above Gatun, and they assuredly mark in so narrow a valley the presence of transverse formations of a character not easily eroded. One understands readily in the light of these facts why the swamps between Gatun and Mindi were submerged frequently so that in old days the natives took fruits by boat across to the Mindi river and Limon Bay. The Chagres was partly dammed back by a cross reef formation.

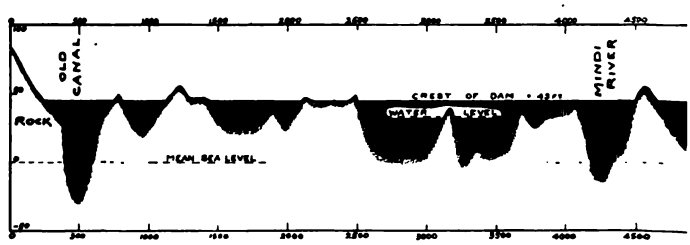
The section of the Chagres disclosed by this profile is 2,586 sq. ft. It is far too small to pass a large flood. So it happened that the river was checked and overflowed the "Swamp of the Quicksands." Part of the water then found its way into the river below the reef and part seems to have occasionally reached Limon Bay via the Mindi to the east of Jaramillo Hill. The Swamp of the Quicksands became a temporary lake. Since the French Canal was opened it has provided a relief for flood waters as well as a new channel.

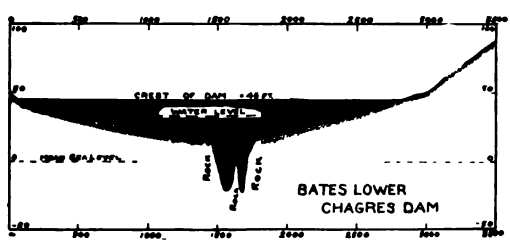
One deduction is safe—the river is going across this reef or ledge by the route of the least resistance.

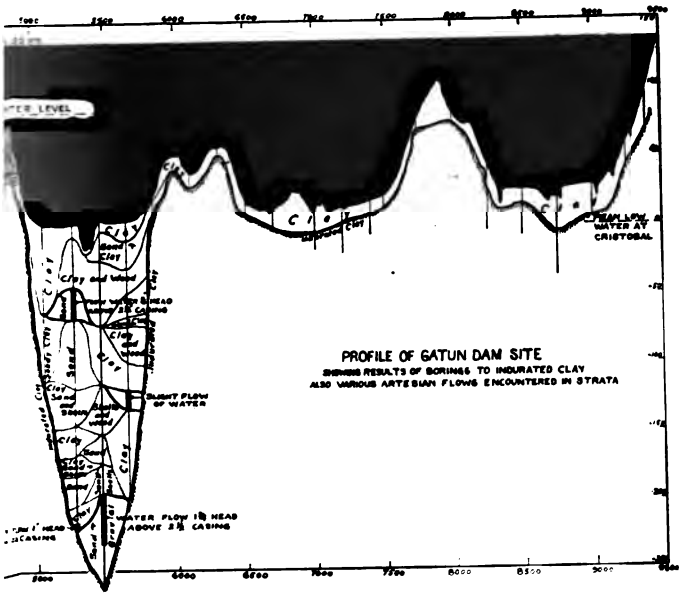
If there were an easier path the outflow of the flooded swamp-lake would have disclosed it. From a consideration of all the factors one must conclude that the reef formation extends from one side of the valley to the other and that the ancient river bed was cut off. One may surmise that in the "Swamp of the Quicksands" the underground waters rise to the surface.

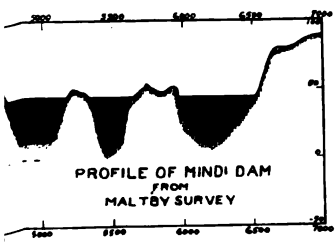
The reef acts as a bedrock dam. Here nature has curtained the underground flow of the Chagres and according to all

CREST OF DAM
LOCKS
SPILLWAY HILL
Sand Shells
Clay


OLD CANAL
ROCK
MEAN SEA LEVEL
CREST OF DAM
MINDI RIVER


CREST OF DAM
ROCK
ROCK
ROCK
BATES LOWER
CHAGRES DAM





COMPARATIVE PROFILES OF DAMS AND DAM SITES TO SAME SCALE AT GATUN, CHAGRES REEF AND MINDI.

available data has provided the site which intrenches a lock canal upon the safe foundations with its main dams solid upon rock.

It also should mean that no great dam is placed at Gatun, no great flight of locks—the most that should be put there is one lock and a small dam with a net head of no more than 30 ft.

The Bates dams at Mindi and on the Lower Chagres are both founded upon the rock. The Gamboa and Alhajuela Chagres—regulating dams are upon the rock. The Pedro Miguel Dam is upon the rock. Has the Government 85-ft. project any such security? If a two-lock project shall be ultimately adopted, and very much recommends this, then every lock and dam is upon the living rock. If a four-lock canal is to be preferred to it, for the reduction of the Culebra excavation, one dam, that at Gatun, must be across the gorges, but it requires only a low head of thirty feet or less. The lower lake created between Mindi and Gatun will blanket the artesian conditions of the under permeable strata and render the hydrostatic pressure from the upper lake harmless. The Gatun Dam would in this case care for only 29 ft. instead of 85 ft. of pressure. The dam upon the reef would sustain but 33.5 ft.—while the underground waters and the hydrostatic pressure from the lakes would be met by the rock barrier which nature has set across the river.

We have the Reef, and with it a safe Panama Canal.

CHAPTER XII.

Reply to Gen. Hains.

The "Crisis at Panama" and the series of articles upon the canal in the New York Press were written in a profound conviction and in a hope that their message might yet avail. The New York Herald of January 20, 1907* announced that General Hains had been appointed by the Secretary of War to reply to these. His answer has been read by the Secretary of War and it is sent as the authoritative statement of facts.

The legate is the most gentle and lovable of men. Were he come representing but himself, the writer would be sorely moved to simply accept his chiding, smile at his toiling defense and shake hands. But he is come authorized to pronounce from the Honorable, the Secretary of War, that certain statements in the Press series and in "The Crisis" are "not true." Silence is, therefore, not within justice to the cause. The facts regarding the technique, the finances and the management of the Panama Canal are to-day an imperative need. This series and "The Crisis" have stated the facts, the exact facts, and not even all the facts.

The Secretary of War's preamble is this:

"The articles referred to are made up of several erroneous statements interspersed among others that are true. The casual reader is unable to detect the true from the false, and thus he must either accept the whole or reject them altogether. * * * His statements are exaggerated and his deductions erroneous. * * * If his premises are not true, therefore the fabric that he has erected upon them must fall."

Manifestly! This is an axiom.

The Secretary of War then separates the sheep from the goats. The writer takes the official sorting and will consider how many of these left-hand exiles must be let over into the right-hand fold. No one deprecates more than the author the facts which he has attested. No one wishes more than he that from beginning to end every one of the charges was false.

But deplored and deplorable as were the truths they are matched in the authoritative denial of them. Nothing proves

* The defense by General Hains came when but fourteen papers of this series had been published. They continued after this reply until March 12, 1907, when they had appeared in sixty-five daily issues of the "New York Press." No further rejoinder was undertaken in behalf of the Lock-flight Project.

so conclusively the canal's need of defense from its official sponsors as the Secretary of War's formal announcement that the statements which he challenges are "not true."

The Secretary's ordered rebuttal is three-fold—personal, technical and financial. The personal is not dealt with yet.

Mere Paper Location.

Technical—First Count.—"That one-tenth of the waterway is a mere paper location is an unfair statement."

We quote:

"The majority excavated along the old canal line, digging down to 40 ft. below sea level. The minority cuts a new line through a series of hillocks made of hard clay. Except at the intersection at the mouth of the Mindi, the minority had in hand from there to Gatun, a distance of nearly four miles, not a single boring on which to base the estimate to which all their responsibilities are attached. There existed neither a profile of the surface nor one of the indurated clay. Their new line is away to the eastward of all canal excavations of the French Company, and therefore away from all accurate knowledge of actual strata."

There is no claim made by the Secretary of War that the board had any borings here. It was a route of pioneering, purely, without any preliminary exploration or test. In the sixteen months since it was adopted but fifty borings have been made in the nearly four miles. Not one of these existed at the board's session. Where, then is the unfairness of the statement? It is an exact and an exactly fair report Further, these fifty borings which have been made in the Mindi-Gatun section show that the guesswork estimates were quite untrustworthy. The borings have so conclusively demonstrated the assertion of "The Crisis" as to the great under estimation of refractory material that already the alignment is changed, and in the "invitation to contract" the proportion of this is set at nearly double that assigned in the minority and commission computation. Here is, then a large increase that has not yet been figured into "Cost." The statement, therefore, that one-tenth of the waterway was a mere paper location is exact.

Borings for Staircase of Locks.

Second Count.—"He states that the locks in flight are

planned with only four borings for data. This is not a fair statement."

We quote the text:

"On superficial knowledge of four holes, therefore, the monster experiment of all time was promulgated by the minority and supported by the commission and the Secretary of War, with all the enginery of the government backing them and announced to the public as safely founded and unassailably intrenched. So reckless and unprofessional a system of engineering could not be found in all American annals."

"This is not a fair statement?" All men even the least technical will appreciate the need for ample certainty as to foundations in locating a masonry structure, weighing millions of tons, which is to attain at its crest a height of 95 ft., and to reach over a mile in length. Till sufficient convincing knowledge as to sub-strata was in hand, no one living could tell even whether or not such a structure could be located at all. Mr. Parsons testified—"You will see the indurated clay, which is the material on which they expect to found the locks and how it will vary in position between the borings. You will see it is liable to fluctuate widely in a distance of two or three hundred feet."

Continuous right foundations were the very "sine qua non" for locating a tier at all. "The Crisis" asserted that this experimental lock flight had been located on the "superficial knowledge of four holes, and announced to the public as solidly and unassailably intrenched." The majority members denounced the location on this identical verbatim statement and the 85 ft. canal was opposed in the Senate because its designing had been done with such utter lack of knowledge and common prudence. When the sea level engineers were scoring the commission in the Senate committee, why, if the Secretary of War and General Hains had other borings on its site, did they not produce them? AND WHY DID GENERAL HAINS TESTIFY THAT HE HAD NOT OTHERS THERE?

General Hains Before Senate Committee.

Senator Kittredge—"How many borings were made in the Gatun Hill in the vicinity of where the locks are to be placed?"

Mr. Parsons—"As a matter of fact, there are four borings, or rather three, that come within the lines of the lock as shown by the minority report."

Mr. Wallace—"There have been only four or five borings taken throughout the entire site on which it is proposed to build those locks which extend upward of a mile in length."

Senator Kittredge's speech—"It will be observed that with one or two exceptions not a boring has been made under the site of the proposed locks at Gatun to determine the foundations."

General Hains—"No sir; I have not seen the borings. I understand that Mr. Stevens has made a number of borings, but we have not had a report of them."

Senator Morgan—"We will have to leave that proposition, as I take it, as the matter stands before the committee now for the want of proper information."

The official map of the Gatun lock site and the dam site is presented in the chapter on the Gatun Dam, with every boring marked which these experts had before them, so that all who count can know. The locks are not on the lines A-B or C-D or E-F. There was not a boring under the two north approach piers—a quarter of a mile each in length. There was not a boring under the north lock with its entrance gate and "safety gate" chambers and their thousands of tons of gate mechanism. There was not a boring under the middle lock and its gate chambers and massive walls. At the upper lock site there were three borings—one in the northwest corner, one in the northeast corner, 320 ft. distant; one in the center—these three holes are all. There were none whatever under the six great gate chambers. The two holes at A and C, on the south brink of the hill, are 150 ft. from the lock gate chamber. There was no boring under the south approach. All the other borings on the lines A-B, C-D, E-F were far away. Would any one bore for the foundations for the Capitol, at the War Department; for those of the Trinity Building, at the Battery; for the Flatiron Building, at the Waldorf; for new Pennsylvania tunnels under the Hudson, in Central Park?

Borings for Gatun Dam.

Third Count.—"That there were no borings for one-seventh of the length of the Gatun dam is not true. There were thirty-seven borings taken along the line of the crest of that dam and they are shown on the drawings submitted with the report of the board."

This boring line lithographed is reproduced in the chapter on the Gatun Dam. It shows on being scaled, as any one can verify for himself, from the east to the westerly end 9,500 ft.

Nowhere in the minority report is this figure of 9,500 ft. of valley width given. There has been no references to any further construction than that on the 7,700 ft. measurement "from the locks to the western end." Of this over 700 ft. was Spillway Hill, so the main dam is roundly 7,000 ft. long.

This map and the precious profile, "the most important document that is in the whole case," show further that the designers swung the west end of the dam 1,000 ft. northward to another spur to shorten the valley width to about 8,960 feet. The profile drawing and chart of the borings reveal that there was not a single exploration or boring in all the west thousand feet under the crucial structure. No stratification profile, therefore, existed, and the location was made with no data whatever for a basis. Surely, before such a dam was indorsed by the minority, commission, Chief Engineer and Secretary of War there should have been some trustworthy and adequate determinations of its actual, not its guessed, relation to the formation. As to "one-seventh" of its computed length, therefore, the stupendous Gatun dam also had a mere superficial paper location.

The entire tally of borings was called for by the Senate Committee in January. It proves that none have been made since November, 1905, save in Spillway Hill. The full story is, therefore, before us. Any man possessed of eyesight can establish the truth for himself. Under the whole stretch of 940 ft. from the lock to the East spur there is seen to be not one boring. The situation was indeed very much worse than the quotation put it. The article of last week on revelations of the later borings showed that there existed for the minority not one boring under the east section; there exists to-day not one boring under the westermost thousand ft.; not one boring under the main crest, in 1,025 ft. immediately west of the locks. This gives not "one-seventh," but actually over three-tenths of the Gatun dam located without a boring. The full tally of explorations shows under the entire main crest, where volume, height and pressure focus its greatest risks, there were and are to-day exactly three borings, two in one place and a third over a mile away.

Comedy of Blunders.

Fourth Count.—"The seriousness with which the draftsman's error has been treated is almost ludicrous."

Yes, the errors involved from the beginning to the end of this Panama matter have struck some in high authority as ludicrous. The comedy works out close to tragedy, though, for the Panama Canal. This "little draftsman's error" in the testimony of Mr. Parsons, Mr. Noble, Colonel Ernst, Mr. Stearns and others proved what? That the locks which had been voted 1,000 ft. usable lengths by 9 out of 11 in the board were in the government plan, when their safety gates were in use—1,000 usable ft.?—or 900 usable ft.? No, at best 820 usable ft. in length.

Mr. Parsons—"I think I can explain Mr. Bates' criticism. If you will scale off the distance from this map, you will find that they have got 900 ft. in the clear between the outer gates but only 790 ft. in the clear between the inner gates."

Senator Kittridge—"And have they accounted for that doubling?" (of gates).

Mr. Parsons—"They have accounted for it simply in that way—by subtracting it from the effective length of the lock. In other words, if the double gates are used, then the lock has an effective length of something less than 800 ft."

Senator Kittridge—What is the length of the largest ship now being constructed?"

Mr. Parsons—"Seven hundred and eighty-eight feet, I think."

Senator Kittredge—"Could that ship go through this lock?"

Mr. Parsons—"It could not unless they left the safety gates off. Then, of course, the criticism comes right back that there is no safety device against a vessel plunging through."

Senator Taliaferro—"What is the usable length of the lock with all the gates closed?"

Colonel Ernst—"820 ft."

Senator Knox—"What would be the greatest length of a vessel which could occupy that upper lock with both gates shut, the safety gate and the regular gate?"

Mr. Stearns—"As nearly as I know, it would be 820 ft."

Eight hundred and twenty-ft. usable locks and the Spooner Act stipulating explicity that the canal shall afford safe and convenient passage for the largest existing ships, as well as for those larger one which shall reaonably be expected.

This was worth revealing to the public, even at the price of being ludicrous.

The errors do not seem to have amused the Senate Committee, however, quite so much as they have some others.

Senator Dryden—"Now, why is it reported to us that the

usable length of those locks is 900 ft. when it is really only 790 ft.? Now, let me understand, is that true?"

Mr. Stearns—"It is possible that between the inner gates it may be only 790 ft. I do not think it would need 110 ft. between gates."

Senator Dryden—"Can you suggest how we can get absolute information as to the usable length of these locks? As regards the work of the committee you must bear in mind that we have to go by the drawings, maps and plans submitted to us. This is a matter, of course, which you are not in any way responsible for." (The designs had been made by another member of the expert board). "But the query occurs to me if we are misled in an important matter like this—and this is certainly a very important matter, as affecting this lock plan of canal—whether we have any security at all in depending upon the other measurements and drawings made here by the draftsmen."

It is now reported that an executive order will insist that the locks must be of 1,000 ft. usable length, despite the labored arguments of the minority and commission for locks of inadequate size.

The Crisis wrote:

Entrance Channels Over Reefs.

Fifth Count.—"Entrance channels located directly over submerged reefs."

The reply is this:

"That the entrance channels are located over submerged reefs is not a fair statement.

"If these were the submerged reefs referred to it may be stated that the channels in Mr. Bates' own project pass over the same reefs."

"If he means that a shoal with 40 ft. of water over it at mean tide—50 ft. at high tide—which is shown on Hydrographic Chart No. 112, Panama road, as extending in a northeasterly direction from San Jose Rock at the Pacific entrance, it is a frivolous criticism, because a slight change in the direction of the channel avoids it. A buoy to mark the shoal would be all that is necessary."

Frivolous criticism, indeed, with a channel much too narrow and too shallow for ships and a sailing course laid out officially across a submerged rock reef carrying, when one reckons the scend of a ship in a seaway but 25 ft.

Depth of Panama Approach.—We make the following quotations from the Advisory Board report. Page 50.

"Beyond this tidal lock there is to be a straight channel

projected into Panama Bay, with a bottom width of 300 ft. and extending for a distance of 3¾ miles to the 45-ft. contour." (Contours refer to mean sea level.)

Page 55:

"The bottom width of the entrance channel leading from deep water off the island of Flamenco to the tidal lock near Sosa Hill will be 300 ft. The depth of excavation in this dredged channel is recommended to be but 45 ft. below mean sea level."

By examining the official tide tables for 1906 one finds that 330 times in a year (27½ times per month) there will be less than 37 ft. in this channel below mean sea level. The time when there will be but between 35 and 37 ft. totals seven days. And there is a much longer total time when the depth is less than 40 ft., the standard, provided at Colon every day and hour in the year, according to both plans of the Board.

On chart No. 1042 are shown the contours of Panama bay from mean sea level outside of the islands. This shows, further, that the approach shoals beyond their terminus and that the 5-ft. contour below mean sea level is a mile farther out. This chart was not before the board, who used chart No. 1950, which does not contain soundings far enough beyond the islands to disclose this condition on the canal axis.

Furthermore, 3,500 ft. beyond their terminus, the sailing line, prolonged, passes over a rocky reef above mentioned carrying only 30-ft. at mean low tide. It is some 750 ft. across on the minority line. This sunken reef runs three-quarters of a mile in a direction 20° North of East from the visible rocks called San José. The chart shows it to extend for 900 ft. directly athwart the entrance line. On the sea-level alignment the reef is over a mile wide and still shoaler.

Now, this reef is where there is positive wave motion enough to affect a large and deeply laden steamer. Hence for practical purposes of navigation it may be said to carry for the minority line not more than 25 ft. at mean low tide or 33 ft. at mean sea level and less for the Majority. The writer adheres to the view that this axial line was wrongly placed from the standpoint of the ship's draft.

This criticism by the writer was published in March, 1906, by the Senate committee, supplementing a presentation to the advisory board in September, 1905. What has happened? This—the official map of December 17 last, "how the canal will look when finished," shows that no buoy to

mark the shoal is contemplated; in fact the line of the expert board is entirely abandoned, as were their Atlantic breakwaters. The remaining engineers have started afresh, and an approach channel is now disclosed which is precisely that put forward by the writer in his presentation to the advisory board in September, 1905, and appearing on page 50 as "Route III via West Trough," from La Boca Pier to the 45-ft. contour. Not only this, but the official information given to bidders tells that the entrance channel is to be 5 ft. deeper than the minority and commission advised in their report. The Secretary of War, therefore, allows that the writer's criticism be officially branded as "frivolous" at the same time that he sanctions the adoption of one of the approach routes that he indicated, avoiding the reef, and the adoption, further, of a channel 5 ft. deeper!

The delegate continues:

Sixth Count.—"He planned the breakwater extending from Toro Point to Manzanillo Point."

Indeed! That is news. If one glances at Pages 97 and 98 of the Bates presentation and Page 1688 Senate Hearings, he will find this breakwater from Toro Point to Manzanillo condemned by the writer unqualifiedly.

"This project for breakwaters across the mouth of Limon bay is chimerical and extravagant." "They must involve a great expense, as they are founded in the deepest water, and must be of much greater volume to resist the sea."

On Plate VI will be found the Bates location from Mindi Point westerly.

If now one will turn to the Isthmian Canal report issued January, 1906, page 294, he will find this statement: "For these reasons the committee unanimously recommended that the plans and specifications be at once prepared for a breakwater extending across the mouth of Limon bay approximately on the line drawn from the light on Toro Point to the Colon light." You see, Mr. Secretary, this is the third to the last set of breakwaters that your own commissions have recommended as the "best and only right" solution for the Atlantic harbor.

Your engineers change advices so frequently that they cannot keep count of their offspring. These were, as you observe, government propositions also, and the board majority and minority had for their very own these leeward

entrance reefs which lie off Colon. The jagged peaks are private and official. No one has intruded upon privileges here. The writer got his channel carefully away, from the reefs and made a safe entrance for the shipping that shall come to the Panama Canal.

No Borings for Breakwaters.

Seventh Count.—"That breakwaters with foundations in unknown and unsearched depths are proposed is also unfounded."

The breakwaters advised by the minority and adopted by the Commission and recommended to Congress are given on pages 67-8, Board Report. They are likewise shown in Plate VIII of the drawing accompanying the Board Report. The text reads:

"The plan of the Board for a breakwater in Limon bay is, with only a slight change, adopted for purposes of estimate. The (Minority) change consists in swinging the long westerly line out from the shore of Mindi Point far enough to permit the channel (500 ft. wide and 41 ft. deep at mean tide) to be made through the easily dredged earth outside the point. The breakwater and channel as modified will be extended to the head of the bay. The distance from the head of the breakwater to the shore line near the mouth of the river Mindi is 4.55 miles." Besides this west 4½ miles, the eastern arm seaward from Colon light runs one mile out."

These are the breakwaters which the parties of the International Expert Board as well as the commission incorporated into their official maps and estimates. How then is this statement unfounded? The commission is surely not going to assert that it has made borings 4½ miles out at sea from Mindi? Nor 4 miles out at sea, nor 3 miles out at sea, nor 2 miles out at sea. One mile out from Mindi mouth boring "N," the outermost boring is opposite Mindi Point. The Crisis said of these breakwaters: "They stretch 4¼ and 5½ miles long, but no one ventures to even guess at the heights from their crests to the deep unknown mud buried bases of their outer 3 miles. Crested rollers at least 25 ft. high must assail obliquely the 3-mile flank of the West arm. Solid 20-ton rock blocks are not obtainable on the Isthmus with which to make safe these sponsored and half-sponsored harbor defending walls. Is it meant to bring granite from the States? Are concrete blocks intended? There is neither sand

nor cement available. It would take argosies of ships to carry sand, cement or 20-ton blocks of stone from any source of supply." Was the statement of The Crisis "unfounded"—the situation was understated. There were actually 4½ miles of the minority breakwaters without a boring.

Now comes the pronouncement, "None may be needed." And none are shown on the map of December 17, 1906. If none may be needed, then what kind of engineering did the full board of International experts and the commission give with five million-dollar breakwaters, designed, estimated, mapped and recommended to the executive? Do the remaining engineers put on and off breakwaters as they do shoes? Is there no science of waterway improvement? Is there no means of knowing whether five million-dollar breakwaters or no breakwaters is the right proposal for a harbor?

Silt Jelly Filling for Gatun Dam.

Eighth Count.—"This story that silt jelly is to fill the heart of the great dam is an extraordinary one to be made by an engineer of Mr. Bates' standing. The statement implies that the constructors of the dam, that is, the Gatun dam, will be both incompetent and stupid."

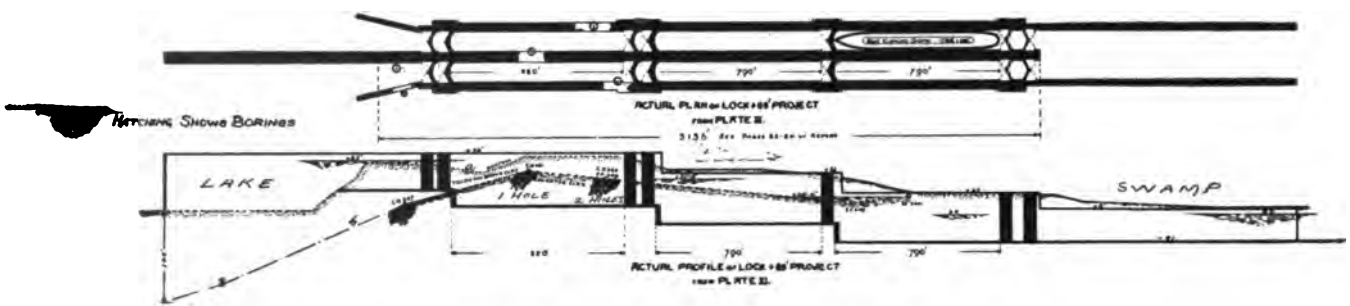
The "story" of it was nothing beside the extraordinariness of proposing it. That was why he felt obliged to draw attention to what was involved. The rebuttal protests here:

"This mud-silt Limon bay material was not to be used in the heart of the Gatun dam."

"The Crisis" said:

"But more of this supply to build this crucial dam is to come from silt dredged in Limon bay. Now, the material in Limon bay is very light and very soft. A rail used for sounding penetrates many feet by its own weight. This silt, jelly-like under the weight of the ocean, will remain mud-jelly in the dam—a sliding cushion for whatever is imposed upon it, and itself molten as lava. This in the heart of the dam, and this dam the heart of the country's project!"

There is no divergence as to the material forming the bed of Limon bay. The delegate himself writes here: "A great number of soundings were taken over Limon bay. These showed that a comparatively hard material is encountered at from fifty to sixty feet below sea level. The material overlying it is a soft one." Yes, many soundings and some six borings—the records are on pages 22 and 23 of the presenta-



PLAN AND PROFILE OF LOCK, 85-FT. PROJECT.

tion of the writer to the advisory board. If material is taken from Limon bay it must axiomatically contain the mud-silt which constitutes the bed of the bay and which is, under the weight of the ocean, as was said, still jelly. This mud and silt proposition for filling in the dam is, however, repudiated, and the writer is scored for imputing to the engineers of the government so "extraordinary" a purpose. The charge is authoritatively contradicted. "Limon bay material was not to be used in the heart of the Gatun dam."

Turn to the Advisory Board Report, page 425:

"Appendix T. Estimates of cost of Lock Canal. (Supplemental to Minority Report).

"Gatun Dam—Earth embankment: Below elevation 50, 12,170,000 cu. yds. of dredged material pumped into dam, at 20cts., $2,434,000.

"Between elevation 50 and elevation 80, 5,770,000 cu. yds. of dredged material pumped into dam, at 30 cts., $1,731,000."

Here is a total of 17,940,000 cu. yds. to be "dredged and pumped"—whence is it to come? The only section whence these dredgings could come is out of the "approach" from the sea to the Gatun Lock flight—a distance of 7⅛ miles, and stated on the same page to contain:

Excavation 40 ft. in depth below low water and 500 ft. wide from head of Limon bay (mile 4.55) to northerly end of Gatun locks (mile 7.15):

Earth (dredging), 10,000,000 cu. yds. at 25 cts.....$2,500,000
Indurated clay (dredging), 2,030,000 cu. yds., at 70 cts. 1,421,000

$3,921,000

"Excavation of channel in Limon bay, 40 ft. in depth below low water and 500 ft. wide, from mile 0 to mile 4.55:

Earth (dredging) 8,300,000 cu. yds., at 15 cts., $1,245,000.

Most of this material is silt-mud.

This dredging excavation totals 20,330,000 cu. yds.

The earth fill of the Gatun dam is estimated to be built from these dredgings, and it requires them nearly all and mud silt and all. The north slope and the south toe will be rock, and the earth fill—the heart of the dam—is between these, so the statements of the Crisis and of these papers is absolutely correct as to the plans of the minority and commission, and the "story" was true.

The Gatun dam mountain is the heart of the government project. Did the country need to be warned against "perversions" of the Crisis or against some other "perversions"?

Was there no need to sound the "intemperate" alarm, mud-jelly a sliding cushion and itself molten as lava? This in the heart of the dam, and the dam the heart of the country's project! The denial continues:

Wonderful Pumping Plans.

Ninth Count.—"That the building of the Gatun dam is conditioned upon pumping material to a height of 80 ft., after piping it a distance of 6,000, is not a fair statement."

"The old French canal, as well as the Diversion canal, west of Gatun, would of course, be used for bringing the material to the foot of the dam, from where it could be pumped to the far side, and still keep the distance at less than 3,000 ft. That it can be pumped 80 ft. with a relay of pumps or pumps in tandem cannot be questioned."

Any one can scale the distance from the intersection of the French canal and the dam and find how far it is to the west section of the dam. It is over 6,000 ft. The old French Diversion and the Chagres, west of the French Canal, are both unnavigable. No estimates for digging out miles of dam-reaching canals have been included. Therefore none have been incorporated. The Crisis says: "A relay pumping system is experimental for this duty, and has nowhere been successfully employed. Unless some other method is adopted or another source of material taken, or a new machine is invented quite revolutionary in its accomplishments, the central "mountain" will never be erected.

Estimates on Impossible Proposition.

Tenth Count.—"That the estimates were based upon the impossible proposition of excavating indurated clay rock with hydraulic dredges is not true. To accuse the consulting board of this intention is frivolous.

The question narrows now. Were hydraulic dredges relied upon for cutting this rock clay—these machines with cutters which it is "frivolous" to suppose experts would ever advise?

The greater part of the material for filling the Gatun dam as given in the minority report, page 425, was to come from the Mindi-Gatun section. In this section the proposed chan-

nel is, as to its width, three times that designed for the sea level project. It ran partly amid clusters of small hillocks and it was closer to the Sierra Quebrancha Hills; hence it was naturally certain to encounter more indurated clay. The majority here possessed all the extensive data of the French excavations in the Mindi-Gatun section. The majority allowed 2,357,154 cu. yds. of refractory material. The minority, with no data whatsoever, not one boring, conjectured 2,030,000 cu. yds. of indurated clay. Fifty borings this past year have revealed that they had much underestimated. This section, therefore, from which most of the material for the dam was taken, was a very important one to dam construction. Self-evidently if machines are to dig out this division they must dig what comes. According to the "Information to Bidders" there is approximately 3,700,000 cu. yds. of this refractory material.

The writer got at Panama himself, from the Mindi-Gatun section, specimens of the indurated clay. When the International Board came out in projects incorporating the excavating of this indurated clay with cutters, he condemned at once with full emphasis the impracticability of the method. He wrote:

"It is the material upon whose rock equivalence the commission is trusting to upbuild for foundations to the massive locks at Gatun. It is the stuff, specimens of which Senator Knox passed around to convince his fellow legislators that it was indisputable rock, when the type vote was concerned."

Mr. Stearns also testified: "As one handles it and looks at it they would call it rock, and that is what it is, a fine-grained rock. I found by taking the knife that I could cut it. It looks something like a fine-grained whetstone, only it is softer than the whetstone that you use."

Senator Knox—I tried the other day with a knife because it looked exactly like soapstone. I got that impression when I picked it up.

Mr. Stearns—For any such pressures as come here that is just as good as the hardest rock that you ever saw.

"Frivolous" Dredging Plans.

Mr. Bates emphatically insisted: "Hydraulic dredges with cutters cannot excavate this Mindi clay rock. Much of the material will have to be drilled and blasted, or Lobnitzed, and the ingenuous proposition to dredge the refractory clay-rock by means of a suction dredge with cutters and put it into barges is, to one with first hand experience in building

and operating, simply preposterous." The delegate writes, "to accuse the consulting board of this intention is frivolous."

The writer called the proposition preposterous. The two are at least agreed that the proposal was an impossible one. It involved $2,500,000 in excavating besides its relation to the construction of the Gatun dam.

Did the board intend using cutters to excavate this material?

It is very "frivolous" in the writer to believe it. "Cutters" are an integral mechanism of an hydraulic suction dredge and of no other type.

Turn to page 419, Board Report. Unit Prices Appendix R. Dredging—"3. Indurated and hard clay requiring cutters."

In the International Board report nearly a page gives the conference regarding the use of hydraulic suction dredges with cutters for excavating the Mindi clay rock. This page is numbered 300.

Plenty of Time, Apparently.

Eleventh Count.—"Mr. Bates takes the commission to task for not sending more dredges to excavate entrances." What a straw man! The Crisis said the commission was amiss in point of view, on the entire system of execution. Men were called to the directorate and engineers to the execution, and these men, being outside hydraulic experience, interpreted construction in land terms, not water terms. A canal is primarily a water proposition. "The Crisis," said, "Let the land area to be attacked and to be traversed be made the narrowest possible and in the least time possible; let the land area to be submerged under lakes be the broadest possible and the submergence be secured the soonest possible. Reduce to the minimum the number of men demanded by enabling floating machines to attack as much of the canal length as is at all practicable." Excavate entrances—straw! Excavate what is necessary to get water plant to work, on a right plan and a right programme of execution.

But the rejoinder here makes an interesting announcement surely. It reads:

"Dredging can wait. Any engineer who will examine into the matter will understand that the work of excavating the Atlantic and Pacific entrances of the canal as far inland as the locks is a simple operation that can easily be done in three or four years. The necessity for doing it now, where

other more important things are to be taken in hand, is not apparent.

"The total amount of excavation in Limon bay is about 8,000,000 cu. yds. If there were any necessity for rushing that part of the work it could easily be put under contract and finished in two or three years. But what would be the use of it after it was done if the other part of the canal were unfinished? It would be of no use whatever, and would be liable to deterioration during the period of its non-use. From the head of Limon bay to the Gatun locks there are about 11,000,000 cu. yds. to be excavated, which can easily be done in three or four years."

It takes nearly all the 19,000,000 cu. yds. here mentioned to build the Gatun dam by the prescribed process. We quote.

Page 69, Advisory Board report:

"The lower part of the dam up to elevation 50 or even to elevation 80 is to be made from material dredged from the canal between the Gatun locks and Limon bay, pumped by a suction dredge into the dam." The commission indorsed this report. Now under the aegis and the authority of the Secretary of War, therefore, it is officially announced in the above extract that the Gatun dam will not be begun until the canal is within four years of being finished! When will it be finished?

"For a whole year after Chief Engineer Stevens went to Panama, he did not know what kind of a canal he was there to build."

Exactly so, and why? Congress adopted in the Spooner Act a definite detailed canal plan, with estimates and every essential for putting the prescribed waterway through. A "chief" went down, and before he got a shovel in place the borings sent the engineering to perdition. The Bohio dam scheme collapsed, and the Panama canal plan was in the air, where it has remained ever since. If little advance could be made in canal construction, who was to blame? Not the American people surely, for they have showered money from start to finish. The engineering has been the canal's handicap. Yes, and if the 85-ft. design is to be executed the handicap will never be lifted.

We turn now to the second category—the financial.

The deficit deductions presented in this series of papers and in the volume "The Crisis at Panama," are put in question by the Secretary of War, and these bases must likewise be vindicated.

"The Crisis" reads:

"Fifty-three millions have been appropriated, of which almost forty are spent. With an outlay of nearly forty millions, the Americans during three years have achieved but one-eightieth of the mass to be handled. The excavation has been in the upper materials; the submerged rock, the indurated clays, the sliding clays, the massive concretes—these are almost untouched."

Page 17 gave the financial statement as nearly as this could be deduced from the Commission's system of bookkeeping. It read:

"Of this $52,956,415 there is inferentially still in hand January 1, 1907, $12,728,207, and there is spent or bespoken $40,228,208."

The Secretary of War's legate states that the estimate of deficits to come "is based on the assumption that $40,000,000 already 'have been expended,' and that the chairman says 75,000 men may ultimately be employed on the pay-rolls. If his premises are not true, therefor, the fabric that he has erected must fall to the ground."

The official answer proceeds:

"That almost $40,000,000 are spent is incorrect. It can be stated authoritatively, first, that $40,000,000 have not been expended up to January, 1907.

"The total expenditures up to September 30, 1906, were less than $27,000,000 and up to January 1, 1907, were about $32,000,000. Of this latter sum nearly $4,500,000 has been for government and sanitation, which are not included in the estimates; nearly $2,000,000 is for public works in Colon, Panama and the Zone, such as waterworks, sewers and street improvements, the major part of which will ultimately be returned by the Panama government to the United States, but are not included in the estimates; $760,000 is a loan to the Panama Railroad Company to enable it to improve its terminal and other facilities; nearly $1,000,000 for individuals and companies is to be repaid to the United States, but which will have to be reappropriated before the commission can get the benefit of it.

"If these proper deductions be made from the total, the sum really expended up to January 1, 1907, is only about $24,000,000. Of this sum about $16,000,000 has been for plant, material and supplies. It seems useless to pursue this phase of the subject further."

Is It "Quite Useless?"—Oh, not quite useless! Let a little further light of the same kind shine on this subject so conveniently dismissed.

Previous statements in this article read:

"There has been expended to January 1, 1907, including the liabilities on orders unvouchered, $40,000,000."

And again:

"There has been expended to January 1, 1907, with the liabilities not vouchered, approximately $40,000,000."

The defense proceeds to segregate a number of items and to announce arbitrarily that they shall not go into the count. In 1903 Congress authorized the then advised lock canal and appropriated roundly $145,000,000 for its completion. On page 68 of the Report of the Commission of 1901 in the tabulated estimates given as the basis for this appropriation stands "Engineering, police, sanitation and general contingencies 20 per cent—$24,038,843." The legislative action since concerned the general type of Canal. The Spooner Act was not abrogated, nor were other bases of construction ordered or a sum higher than $145,000,000 authorized. The Secretary's delegate now announces that Canal expenditures must not reckon in "Sanitation." It must not either reckon in "Zone Government," "policing," etc. It must not reckon what has been invested in trying to make Colon something different from the pest hole it formerly was. If sanitation is to be counted out today, and tomorrow zone government and policing, and the day after the drainage of Colon, and after that the supplying of water, there is no reason why there should not be further thrown overboard—supplies, equipment, labor or any other indispensable items. One thing is certain, they have no longer got this money to spend. It is gone or pledged, and the commission, having around 12½ millions free a month ago, has called for 25½ millions more for the next fiscal year, and this is the heart of the matter.

Deliberately Exceeded Legal Limit.—The authority of the commission to spend money on sanitation and zone government rests on the Spooner act, and the sums so expended must be audited on that specific basis and charged to appropriations in pursuance thereof. If the Spooner act is superseded, and expenses as to these items are not counted against its 145 millions, pray where is the authority to

devote any money to them at all? The idea is, of course, to raise the canal resources and make an undefined draft later, on the treasury to cover the two elastic and pervasive items. "Sanitation and zone government are not in the estimates," the explanation reads. The advisory board and commission just left them purposely out. But Congress never sanctioned this basis of making estimates. There exists no legal warrant anywhere for cutting sanitizing, policing, governing, etc., out of the canal count. They are canal work and as incident to construction as any other items in the long schedule. Were the American people let know that there was this vast uncounted increment which must be provided for, outside the $145,000,000? Turning to the Financial Exhibits, we notice that the bookkeepers are still charging sanitation and zone government up to canal moneys and the authorities are obtaining funds from the treasury by warrant of the Spooner act and appropriations thereunder and with no claim of other sanction. Sanitation and zone government, therefore, belong where the commission has itself set them in the reports and where the "Crisis" likewise added them, namely, among the expenses incident to canal building.

This article has wished to be ultra conservative. As the rebuttal states, "If his premises are not true, therefore, the fabric that he has erected must fall to the ground." The writer was most cautious of his premises. Further, he wished the best for the Panama canal and he allowed the commission every lattitude in figuring. In his "premise" he counted the two items "sanitation and zone government" one million a year. The Herald letter states authoritatively that $4,500,000 have gone into sanitation and zone government.

Exhibit F of the Isthmian report gives this:

Government and sanitation July 1 to Sept. 30....	$ 633,263.50
Average per month	211,087.83
Total to September 30, 1906	3,643,738.97

Secretary Needs Another Defense.—Now, three months later, these are given as $4,500,000, which makes the items for October, November and December (three months) $856,261.03, or, on an average, $285,420.34 per month, when only 27,000 men were on the rolls. Evidently when the 25,000 additional announced in the message arrive, the cost

must be very much increased. Yet at only the above rate, the total for sanitation and zone government would be in the eight years $27,400,320. Twenty-seven and a half million! The writer, giving the broadest indulgence in his bases, counted against the government here but nine millions for sanitation and zone government combined. (Page 19 Crisis.) This outlook revealed by his delegate is so much worse that the Secretary of War may have to appoint another to defend the public against him.

To continue, first quoting from the authoritative statement:

"About $2,000,000 is for public works in Colon and Panama zone, such as waterworks, sewers and street improvements, the major part of which will ultimately be returned by the Panama government to the United States, but which are not included in the estimates."

We analyze a little further. The report chronicles payments on

Public works to September 30, 1906	$1,609,869.43
Of this was spent in the United States territory	253,871.08
Outside United States territory	1,355,998.35

Now, pray, by what warrant are these expenses made outside the zone, except as sanitary measures covered by the Spooner act? The commission is surely not a philanthropic board. It was not constituted a commission of general public improvement to the Republic of Panama. These are features undertaken incidental to the canal in some way, else they have no warrant for being. Further, the money has been expended, the funds are gone; that is beyond peradventure. As for getting the cash back—well, perchance—we notice there has been rather strong kicking at the hint and complaints of excessive cost. Till the money is actually returned it is an expenditure out of the canal appropriation, and must be counted as such. These items are just as necessary parts of the canal enterprise as a commissioner's salary—even a little more so. They belong by all business bookkeeping in the canal's present expenditure account.

Money Spent Counted as Cash Asset.—"Seven hundred and six thousand dollars is a loan to the Panama Railway."

We turn to Exhibit D, page 121—the General Balance Sheet, and find an item, "Advances to the Panama Railroad

Company on account of current indebtedness, A$782,843.23."

Then the footnote A runs thus: "This amount is disposed of when vouchers are audited and distributed to expenditure accounts!" In other words, lend a man $782,843 to spend for you and know and record that he has spent it and then call it a cash asset until he takes the time to turn in his expense vouchers. It helps the balance sheet on window-dressing day—as Congress meets.

Then there is the loan item "loans to the Panama Railway Company, September 30th, $580,000." Has this grown January 1, 1907, to $760,000? The commission used to get loans from the railway when it was hard up from the fatigue of buying things. Now they take it from the right trouser pocket, put it in the left-handed one, where it is spent for "facilities" to build the canal, else again, how is it legal? They dub it a loan. It is spent just the same.

Again, September 30, 1906, there was in the hands of "individuals and companies," $711,692.90. January 1, 1907, this has grown to $1,000,000. This item is without detail. It is not anywhere explained in the whole report. It is to be repaid to the United States, but it will have to be reappropriated before the commission can get the benefit of it. What is it? Who has $1,000,000 of the government money in this way—and why?

He continues:

"If these proper deductions are made from the total, the sum really expended up to January 1, 1907, is only about $24,000,000, of which $16,000,000 is for materials and supplies."

We take from the balance sheet of September 30, 1906, the following:

Current assets, $26,024,682.08.

Five Millions in "Unvouchered Accounts"—But these are net assets; they do not include the unvouchered accounts—payable, contracted, etc., and other liabilities. These, on June 20, amounted to $5,431,326.71, Exhibit E of the report. There is no report of this to September 30, nor in the explanations of the Secretary and Commission through General Hains.

If it was about the same September 30 as then, the total net cash left not bespoke by outstanding orders and by liabilities unvouchered or unscheduled may be estimated thus:

$26,024,682.05 less $5,431,326.71 less vouchered liabilities, $1,234,856.27, equals $19,358,499.07 not expended or pledged.

The expenditures for the three months ending September 30 were $5,324,378.02, hence if we take this sum from the above for the expenses of the past three months, we have roundly ($19,300,000 less $5,300,000) or $14,000,000, which was about the resource clear of debt. This from total of appropriations and "receipts," $52,500,000, is $39,500,000 expended or bespoke. This is coming pretty close to the "around $40,000,000" which was reached by another process in the complete absence of details as to the amount of the "unvouchered accounts."

Turning to the report of Hon. Leslie M. Shaw, Secretary of the Treasury, the following item appears on page 3 under payments from the treasury for various accounts:

Panama canal, 1905	$ 3,918,819.83
Panama canal, 1906	19,379,373.71
Total	$23,398,193.54

Deducting this from the total of the appropriations of Congress, there was undrawn June 30, 1906, $29,049,007.54.

Against this must be reckoned:

Actual expenditures, 3 months, July 1 to September 30	$ 5,324,378.02
Estimated expenditures, 3 months, October 1 to December 31	5,324,378.02
Unvouchered liabilities and accounts to June 30, taken to be about the same January 1	5,431,326.71
Net current liabilities (page 121)	1,215,487.54
Total	$17,295,570.29
Roundly	17,300,000.00

Forty Millions Gone Glimmering.—Deducting this from the undrawn balance in the treasury on June 30, of $29,049,007.50, there remains $11,750,000, closely, as the actual credit in the United States treasury clear of obligations. In addition there was, say, $1,500,000 in the hands of the canal disbursing officers. Adding this we have $12,250,000 as the free money—out of $52,500,000 appropriated. This again indicated that "almost 40 millions" are gone glimmering.

Under date of December 31, 1906, there stood to the credit of the Isthmian Canal Commission, in the United

States treasury, $18,042,979, and under date of January 26, 1907, but $15,937,478, out of which comes the unvouchered liabilities. There was withdrawn during twenty-six days, $2,105,500.

Take still a third line. The Secretary's delegate states in the letter, "Up to January 1, 1907, about $32,000,000 were expended." Reference to the millions of unvouchered accounts and other liabilities of the commission was carefully omitted. The payrolls and the $6,700,000 of such liabilities on June 30 would bring the total again $39,700,000 of actual moneys run like water through the mill. The nearly $40,000,000 of the press articles and "The Crisis" is checked by three systems. It is already ancient history, as the amount is now over $40,000,000—February 1.

"Of this sum about $16,000,000 has been expended for plant, material and supplies," the letter says. The articles and "Crisis" gave $20,000,000. Let us see. Exhibit C., Annual Report of Isthmian Canal Commission.

Total to September 30, material, supplies, etc., issued	$ 9,353,210.15
Total to September 30, material, supplies, etc., on hand	3,785,454.16
Total to September 30, material, supplies, etc., steamers	1,312,872.67
	$14,451,536.98
Unvouchered accounts, partial payments before delivery, etc., from page 122, this estimated at	5,500,000.00

Hence, September 30, we deduce about $20,000,000. Pretty close to the $20,000,000 of the "Crisis."

The letter affirms positively that $16,000,000 has been expended (that is, paid out). It carefully leaves unrecorded what is due on plant, materials and supplies ordered, but not delivered, or delivered but not vouchered. The writer opines that by that date, January 20, the twenty million was considerably overtopped.

The bases, then of the article and the Crisis were true and very close approximations indeed, when one has to dig his facts out of such bookkeeping. "Many millions of unvouchered accounts" is not encouraging in a trust.

In view of the expenditures and liabilities reaching nearly or quite forty millions, which are actually being paid out of the Spooner appropriation and for whose continuance the commission is asking 25½ more millions, the basis upon which the writer's structure has been built is seen to have been accurate.

How Many Men Will Be Needed?—Next as to the impeachment of another adopted basis—the labor unit.

"And second, that the chairman of the commission never stated that ultimately 75,000 men might be required. Neither the chairman nor the commission believe that such a number will ever be required. Half that number may be, but it is not likely that more than half will be employed when the work is in full blast."

It was stated at the beginning that the writer knowing the vast deficits, which at the very best, his calculations would set against the 85-foot project under its present system and management, took his bases with every possible conservatism and every possible latitude and indulgence to existing things. By a comparison of French with American construction records he showed (page 5) this:

"The best month in nearly three years' experience of American management gave 289,000 yards. This represents less than one-half the French output with over twice the French force."

He had every warrant for taking as a basis the American output. But did he? No. He wrote (page 6):

"We will in all calculations allow a man the efficiency of the French rather than the deficiency of the present system, and rate him 70 cubic yards a month."

Here, then, was a first concession of several times what the real output was reaching. With this indulged 70 cubic yards per month per man, taking the full excavation, he divided and showed that to do the work in eight years "will take an additional force of 31,000 men." "On such a basis at least 31,000 men will be required in addition to the present force now presumably fully employed. This totals 61,000.

Again:—

"The contingent of laborers which, at the relatively high rate of output of the French in 1886 must be kept at the Isthmus in addition to those now employed, was shown to be 31,000. If the efficiency during three years past be taken

as a standard, it must be very much higher." Did he take even the 31,000 additional as a basis for his calculations? No; he gave a second margin of conservatism. He wrote:

"The commission report gave 25,000 men on the payroll in the spring. On his return from the Isthmus in the autumn the chairman stated the number as around 30,000 then, while 75,000 might be ultimately employed."

"The message puts the average force for the last ten months as 26,680, and officially announces that 25,000 additional are to be put on. The labor contingent is to be, therefore, at least doubled."

Was the President Wrong?—From this the delegate reports, Mr. Bates writes, "that the chairman of the commission says 75,000 men may be ultimately employed on the pay rolls." "On this as a foundation he built up a fabric of inferences," etc. Ah, no! he never built any of his foundations on the chairman's convenient vauntings. He built his fabric in its labor basis upon the commission's latest report and the last presidential message.

The message of December 17 is only six weeks old. Its pronouncement should be of some authority. Page 23 states that the number of employes was, July 28,041, August 29,555, September 28,264, an average of 28,620 employes. On page 13 is the following precise announcement:

"At present 25,000 men are engaged on the task. After a while the number will be doubled."

Even the 31,000 additional force needed for hastening execution of the pace demanded for an eight-year completion was not counted as the basis of Mr. Bates' calculations. He said "despite the unescapable mathematics, let us not count 31,000." He dropped yet a second time and figured only this 25,000 announced by the president.

"One hundred and ninety-two million dollars are to be paid out in wages alone, if 50,000 men are to be at work at Panama—$192,000,000 for the eight estimated years."

This, then, the 25,000 men announced in the message was the basis of the calculations in which three hundred millions in deficits and interest were to be left to posterity.

Now, the delegate of the Secretary says:

"Neither the chairman nor the commission believes that such a number will ever be required. Half that number

may be, but it is not likely that more than half will be employed when the work is in full blast."

Is one to accept this belated and less authoritative announcement?

If 37,500 are all that will be employed when the work is in full blast, why with the present 27,000 men, and numerous recruits that are now so triumphantly announced from Spain, together with the recruiting from all available islands, is there at Washington a contract drawn for a contingent of 15,000 Chinese to be kept to the privileged full quota? Why is the country's money being spent in recruiting men if they are not to be needed? Why are contracts drawn if it has all along been known that these labor units will never be required? (Col. Gorgas' Report gives Sept. 1, 1907, "slightly over 41,000 men on the rolls.")

"It is important to bear in mind that while the payroll may show 30,000 men employed, there are not more than 60 per cent who draw pay weekly."

Wage Estimates Carefully Made.—Contractors are apt to be painfully aware of this difference. But it will be allowed that the proportion of the force which is paid is represented in the wage account. The wage estimate in this series was not figured on the individual man, as will be noted. It was carefully taken from the Annual Report and the Canal Wage Schedule. The payroll given in the report is, exclusive of collateral railroad work, roundly $800,000 per month, and the force was to be doubled. Contractors were to be brought in and the work pushed to "distraction."

Did the writer in making a basis double the payroll in doubling the force? No; a third time he gave a large saving margin; $1,600,000 a month was double the wage account. He cut off $100,000 a month and based his estimate, it will be observed, for the eight construction years at $1,500,000 per month, or 144 millions in wage alone.

If now some unannounced method has been discovered whereby "but half the number of men will be required," it is excellent business, indeed. Why was the President not allowed to add to his message this cheering Christmas hope?

The Crisis wrote:

"With an outlay of nearly forty millions, the Americans

during three years have achieved but one-eightieth of the mass to be handled for their large canal. The excavation has been in the upper materials—the submerged rock, the indurated clays, the sliding clays, the massive concretes, these are almost untouched." "The ratio between 'money expended' and 'work done' in the French accounts was the handwriting on the wall."

Ships can pass at the Isthmus only when they have a canal to pass through. The advance of work in a last analysis is figured in the amount of execution on the canal itself. It is allowed freely that multitudinous collateral things must be done. But it is seen now, February 1, 1907, nearly three-tenths of the money has gone and in three years but three-hundredths of the excavation and embankment work has been handled. Then the defense demurs because the inevitable deficits are pointed out, and he says nothing of these whatever.

In the official glamour all is triumph. "The canal has swept from chaos to contract. It will surge from contract to completion." Is all well at Panama?

NEW YORK PRESS EDITORIAL.

February 23, 1907.

Panama Canal Deficits.

Early in Mr. Bates' Panama series running in The Press it was said "fifty-three millions have been appropriated, of which almost forty are spent. During the three years the Americans have achieved but one-eightieth of the mass to be handled." Article VIII. repeated "There has been expended, including the liabilities not vouchered, approximately $40,000,000." The Secretary of War appointed a [illegible] to reply to this assertion among others. The [illegible] letter was approved and given out as the administration's announcement. It read thus: "Mr. Bates' estimates of deficits to come are based on the assumption that $40,000,000 already has been expended. That almost forty millions are spent is incorrect. It can be stated authoritatively that $40,000,000 has NOT been expended up to January, 1907. The total expenditures up to January 1, 1907, were about $[illegible]. Of the latter sum $[illegible] has been for government and sanitation, $[illegible] for public works in Colon, Panama and the Zone. $[illegible] is a loan to the Panama Railroad, nearly

$1,000,000 for individuals and companies; $16,000,000 for plant, materials and supplies; $24,000,000 for canal proper."

No figure was put in or any hint given of such an item as an outstanding "unvouchered account," to be added into the outlay. The $32,000,000 itemized in part by the delegate was the authorized statement of the Secretary of War to the public.

The Chairman of the Commission, Theodore P. Shonts, speaking at Kansas City, on January 24, gives out officially a second time this same statement. "In this preliminary work we have spent down to January 1, 1907, about $32,000,000."

Notwithstanding these concise denials, the series, deducing from evidences of past Isthmian reports, insisted that there was an item of "unvouchered accounts" which would bring the amount "expended or pledged" up to its reported "approximately forty millions!" Within the past few days some of the legislators at Washington, in view of the deficits which can no longer be masked, asked definitely, as their privilege permits, regarding these "unvouchered accounts." The reply sent by the Secretary of the Commission is this:

Isthmian Canal Affairs. Office of Administration.
Panama Canal Building.
Washington, D. C., Feb. 14, 1907.
Please refer to File.

SIR—By direction of the Chairman, I have the honor to refer further to your letter of January 29, 1907, asking as to the amount of unvouchered liabilities of the Isthmian Canal Commission on January 1, 1907, and for some general idea of the items composing such sum, acknowledged under date of the 11th instant, when you were informed that a part of the information would have to be obtained from records on the Isthmus.

I have now respectfully to advise that on January 1, 1907, the commission had entered into contracts and issued formal purchase orders, the unsettled amount of which on that date was $6,072,557.33, consisting of orders for miscellaneous material and supplies and equipment issued at Washington, $6,051,831.39; those issued at New York, $13,548.11, being largely for furniture and commissary supplies; orders issued by the Army Medical Supply Depot at New York, for hospital and medical supplies, $5,941.64, and miscellaneous orders issued by the Assistant Purchasing Agent at New Orleans, $1,236.19. The unsettled balance for orders issued at Washington includes $786,000 for locomotives, $1,168,000 for flat cars, $430,000 for dump cars, 145,000 for steel rails, $201,000 for three dipper dredges, $725,000 for two suction dredges, $250,000 for barges, $104,000 for steam shovels, $98,000 for repair parts for steam shovels, $66,000 for earth spreaders, $257,000 for lumber, $85,000 for cement, $68,000 for boilers, $95,000 for steel roofing, the remainder being for miscellaneous articles of lesser value, including switches and frogs, steam drills, air compressers, road rollers, lathes, sewer

and lead pipe, tiling, plumbing supplies, bar and wrought iron and steel, sheet lead, white lead, oil, hose, rope, furniture, beds, bedding, tents, hay, oats and miscellaneous office and other furniture and supplies.

Besides this indebtedness there was due to the Panama Railroad Company for miscellaneous supplies service, transportation and for work done in the construction of the second main track on the Isthmus, for which the commission will pay $1,578,000; there was also due for miscellaneous material and supplies and miscellaneous service on the Isthmus approximately $100,000. MAKING AN AGGREGATE OF UNVOUCHERED INDEBTEDNESS JANUARY 1, 1907, OF $7,750,000.

It will be understood that the foregoing includes all executed contracts accumulatively to date, some of which have extended over a long period of time and provide for deliveries for some months ahead.

I trust the foregoing will meet your requirements.

Respectfully,
JOHN BUCKLIN BISHOP,
Secretary.

"An aggregate unvouchered indebtedness January 1 of $7,750,000!" This ADDED TO THE $32,000,000 GIVES $39,750,000 or "almost forty millions."

While no word of unvouchered liabilities appears in the printed report of the hearings of the Secretary of War and the officials of the commission before the Appropriation Committee of the House or the Senate Committee on Interoceanic Canals or the House Committee on Interstate Commerce, nevertheless, on page 927 of the Appropriation Committee hearings, columns 5 and 6, 7 and 8, it is shown that they contemplate exhausting by June 30, 1907, every dollar of the fifty-three millions already given in expenditures and liabilities.

In the next fiscal year $25,211,258.78 is to go, which will leave only about sixty-seven millions, and still years and years of construction to be provided for. Since the above was written a call was made for 8 millions in September, 1907, and 32 millions are to be appropriated by the coming Congress. These calls leave but $25,000,000 of the original estimate to last from June 30, 1909 until the canal is finished!

CHAPTER XIII.

MINDI-GATUN SECTION AND ITS RELATIONS TO GATUN DAM.

Having considered the Atlantic harbor and terminal city, it is in order to move inland and discuss the section from Mindi on the south shore of Limon Bay to Gatun. It has been mentioned incidentally that the route of the 85-foot project is not here along the French canal.

The Majority locates along the old line, digging down some 40 feet below sea level. The Minority channel crosses the former near the shore and runs at the beginning amid a series of hillocks of hard rock-clay.

Except at the intersection at the mouth of the Mindi the minority had in hand, from there to Gatun nearly one-fifth of the total land length to be dug, not a boring on which to base the estimates which were incorporated into their report. There existed neither a profile of the surface nor one of the indurated clay. Their new line was away to the eastward of all the canal excavations of the French company and away from all accurate knowledge of the geological formation.

The Majority conceded 2,357,154 cubic yards of clay-rock material in their own line to mile 5.49. The line of the minority was closer to the Sierra Quebrancha hills; hence, it was certain naturally to encounted more refractory material than in mid-swamp. But its sponsors claimed to have in their excavations between Mindi and Gatun less indurated clay than that which the majority conceded. The writer declined to credit that the minority had figured at all enough refractory excavation. He concluded from a careful study of all available data that between Mindi and Gatun especially, the quantities allowed by the minority were far too small, and so recorded.

Estimates Vastly Underrated.—From an examination of all pertinent maps and a familiarity with the history of the abandoned French river-diversion, and from the accuracy of the data on the old canal alignment, remembering that on this section the minority project is over three times as wide as the seal-level project and that it runs amid these clusters of small hillocks, it became almost a certainty that the indurated clay in the minority's estimate was vastly underrated, but by what amount no one could know. He

recorded in March, 1906, that when this line was actually surveyed, if it ever was to be, and bored, it would undoubtedly be found that the minority would have over double as many cubic yards as they then estimated of clay, refractory from a dredging standpoint.

Their curve between Mindi and Gatun had to be over 700 feet wide at the water line, and this expanse was located right at the hard, hilly knobs with clay-rock which stopped the French diversion excavations. The amount of clay-rock digging was, therefore, manifestly miscalculated. The government experts merely guessed at it, for as was said, they had no rock-clay profiles or even surface-profile data. Two of the very same experts are the elect who went "in April, 1907, to precisely locate the locks at the various sites!"

This location of the 85-foot design is 500 feet wide on the bottom. One may see from the profile of Mindi Gap some of the hillocks rising to 50 feet above the sea level. The cutting in places, will be 810 feet wide. At the curve (mile 5¾) it must be still wider, and the material must inevitably be exceedingly difficult to handle.

First, the top stratum, with roots and vegetation, will not deposit well or easily in barges if an attempt be made to load such by hydraulic dredges.

Second, hydraulic dredges with cutters can not excavate this Mindi rock, found at a depth of 18 to 20 feet. It is the stuff of "soapstone" or "whetstone" quality on whose rock equivalence the commission is depending to upbuild foundations for their flight of locks. Much of it will have to be drilled and blasted or Lobnitized, "and," the writer wrote in the "Crisis," "the ingenuous proposition to dredge this refractory clay and rock by means of a suction dredge, with cutters, and put it into barges is, to one with first hand experience in building and operating, simply preposterous."

Such material must be severed from its bed and put into barges by dipper or, preferably, by a multiple-bucket dredge. With such machines much of the stuff deposited into barges will be in large lumps, in sizes up to a cubic yard or more. The material manifestly is in no condition for being "pumped from the barges into the dam." It must be granulated first mechanically. To such service the cutters of a suction dredge at dam stations are not suited either. The writer knows of no way of effecting this save by some

cumbersome process of stamping, crushing or granulating untested under such conditions and inevitably very expensive.

It will be recalled that in a previous chapter confuting a reply to certain statements of this series, the tools assigned to the duty of excavating the Mindi clay-rock were discussed. It was officially asserted as untrue "that the estimates were based on the impossible propostion of excavating indurated clay with hydraulic dredge cutters." But there was incorporated from the records of the full board the verbatim phrase:

"Indurated and hard clay requiring cutters."

BATES' HYDRAULIC DREDGE, WITH CUTTERS, NEW YORK BARGE CANAL.

Unit Cost Will Be Much Higher.—Attention was drawn to the fact that page 300 of the International Board Report gave the conference whereat the details were discussed for using "hydraulic suction dredges with cutters" upon this clay-rock. Since the commission now at last utterly repudiate the International Board's implement for this service. they are manifestly under the need of providing some

other system for excavating the clay-rock. They concede that they cannot cut it by means of the cutters to which they trusted for getting the price down to 70 cents, which is one-half to one-fiftth of the prices for underwater rock. Considering the type of plant which will have to be substituted the unit cost will self-evidently be very much higher.

In the Colon harbor bids, more than two years ago, one firm, practical and experienced in the art of dredging by suction and with other types of dredging machines, spent months of time and thousands of dollars investigating and boring. Annual Report Isthmian Canal Commission (p. 251) states:

"The chairman read a communication from the chief engineer, dated December 29, 1904, respecting the conduct of an agent who had been given permission and assistance in taking borings and gathering special information regarding the harbor of Colon, asking in reference to course to be pursued when such agents decline to return the courtesy and refuse to give data so obtained. The matter was referred to the chairman for reply."

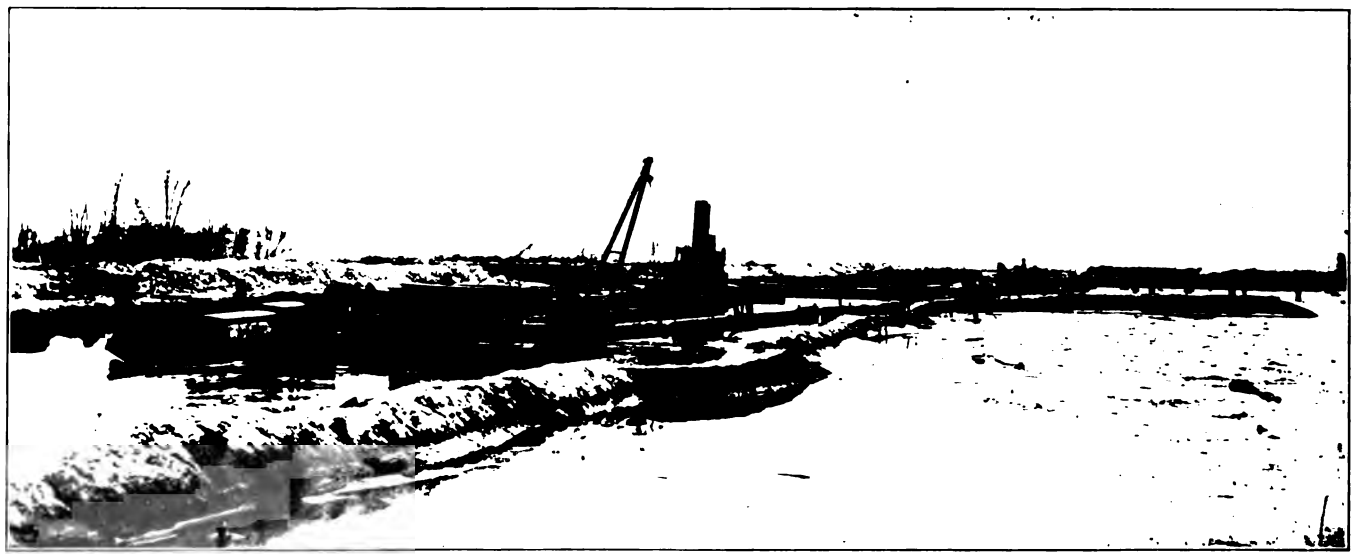
Then in a competitive tendering this company, thus fully prepared, bid $1.50 per cubic yard for excavating and spoiling merely upon the adjacent bank. (Vide Engineering Record, June 24, 1906.)

The Mindi-Gatun spoil must be, in addition, transported to the Gatun dam site, for the experiment of building the dam hydraulicly is, it seems, still to be tried. This hydraulic method was the process definitely proposed and detailed in the board report and accepted by the commission.

The official description read as follows: "The lower part of the dam up to elevation 50, or even to elevation 80, is to be made from material dredged from the canal between the Gatun locks and Limon bay, pumped by a suction dredge into the dam." (Board Report, page 69), "and the quantity to be so dealt with totals 17,940,000 cu. yds.," about 27,000,000 tons.

Knox Confirms the Process.—Senator Knox confirms the process in his speech advocating the lock type in the Senate:

"It is proposed to construct this Gatun dam entirely by the hydraulic or water sluicing process, the material being taken largely from the prism of the canal between the dam and Limon bay, being largely clay with some fine sand.



BATES' HYDRAULIC DREDGE "ONEIDA," NEW YORK BARGE CANAL.

"This point is emphasized in consideration of the proposed method of construction, namely, that this earth is not to be put in loosely, but to be put in by sluicing with water."

The testimony of Mr. Stearns before the Senate committee, when being examined as to the process, further corroborates this specified method. (P. 1901.)

"The water would not be brought down through sluices by gravity, but would be pumped up by these pumping dredges."

Senator Morgan—Like those Mr. Bates is using at Galveston?

Mr. Stearns—Yes, sir; that same idea.

These are the only machines of this type in the United States, and one is the largest of its order in the world. They are engaged in the work of raising the city. It may surely be conceded that the writer who is in direction of this execution is likely to attest with some knowledge and experience what the dredges can and cannot undertake.

What are the Minority's requirements? First as to distance. It may be seen from the detailed map of Gatun, that the nearest point from which a dredge or discharge barge could have access to the dam, would be where the old canal line and the Chagres river meet, i. e., at the lower extreme northeastern edge of the dam. No closer approach is possible unless special canal extensions are excavated and the shallow river channels are opened. In addition to the great and entirely uncounted cost such access channels even so small as 250 feet wide and twenty feet deep along the foot of the dam, would so enlarge the opportunity for destructive percolation and weaken the base that they evidently should not be ventured. The point above mentioned, therefore, is the nearest that channels should be allowed; let a radius sweep a curve which will include the whole length of the dam. It will be seen that this radius must be fully 6,500 feet long.

Impracticable Process.— By the experts' description given above the heights through which it is proposed that material shall be pumped is up to 80 feet probably, and 50 feet certainly. This is the task for whose accomplishment they rely on such as the Galveston dredges—a 50 to 80-ft. lift at the end of a mile and a quarter of pipe line. The Galveston dredges or any others ever built might as well try to pump to Greenland. Further, increasing their size would not enable them to do it, because of

the mechanical limit of the method. The Galveston order is not at all the most efficient type for this Gatun Dam proposition. But, even with the best, the highest accomplishment yet recorded is a 35-foot lift at the end of a 2,000-foot discharge pipe. The practical limit of the largest dredge at Galveston is, at the end of 4,500 ft. of pipe, a 12-foot lift, which she will reach in filling the far west end of the city. None of the other three dredges can achieve even this, which is the record of the largest and most successful example of the type yet evolved. So they must be ruled out and the material be handled some other way.

In addition, then, to digging the Mindi clay-rock by a system different from and costlier than that of suction dredges with cutters, it must be transported, some of it, four miles to Gatun. At Gatun below the dam what is the next step? Is it proposed to raise this material intermixed with great clay-rock chunks by "tandem pumps." There is no reference made anywhere to the treatment awaiting the spoil. Yet it is surely a very important and interesting detail this, of the situation at the foot of the dam preceding construction. How is the stuff to be put into condition to be pumped? The engineers deal in splendid alluring generalities and base their estimates upon magic, but they nowhere deign to come down to the plain man's earth and reveal how they will achieve their feats. How is the clay-rock to be treated? At this point it is evident that the government's dam was to be conjured into being by way of the untried and has been gambled upon the undemonstrated.

In a pronouncement to throw light upon dark places, it is averred that its pumpability is beyond question. When it is replied that "a relay pumping system is experimental for this duty and has nowhere been successfully employed," why, in rebuttal, is not one instance meeting the Gatun conditions adduced? If it is so beyond question it must be easily demonstrable.

Proposition Has Not Been Tested.—The truth is that in no place has this proposition of granulating such indurated clay, mixing it and pumping it by relay to 50 or 80 ft. had a single test, let alone a victory.

The board adopted some unit prices, which assigned to this material when it was to be dug by an "hydraulic dredge with cutters," 70 cts. per cu. yd. (Board Report, page 410.)

Dredging.	Price per cu. yd.
Mud and sand in Colon and Panama harbors.....	$0.15
Soft material removed by hydraulic pumps in canal....	0.25
Indurated and hard clay requiring cutters.....	0.70

It added:

"It must be remembered that any estimated price is only approximate and should be made high enough to guard against errors, and will then be high enough to cover small variation from average conditions. It is recommended that the prices be used broadly."

The experts and commission then went before the public with the following estimate, based as was shown, upon using hydraulic dredges:

Mile 4.55 to Gatun.

Earth 10,000,000 cu. yds. at 25 cts.	$2,500,000
Indurated clay 2,030,000 cu. yds. at 70 cts.	1,421,000
12,030,000 cu. yds.	$3,921,000

Indurated clay was, therefore, rated at approximately 20% of the material.

Borings Increase Estimates.—During the months following the report some fifty borings were made through this swamp, and the result of their revelations was embodied in the information to contractors issued in November, 1906.

"Mindi-Gatun section 11,000,000 cu. yds. of excavation, of which one-third, or 33 1-3 % is indurated clay." Let us examine how the second official announcement works out first at the above unit prices.

Mile 4.55 to Gatun.

Earth 7,333,334 cu. yds. at 25 cts.	$1,833,334
Indurated clay 3,666,666 cu. yds. at 70 cts.	2,566.666
11,000,000 cu. yds.	$4,400,000

There is now, therefore, an increase of $479,000. But at a price commensurate with the substitute type of plant which must be provided and the cost of excavation the difference becomes not $479,000, but at even $1.50 per cu. yd. it totals $3,412,334 over the expert estimate. This leaves out all the macerating and pumping accretion to unit costs. The cutting here is but 500 ft. wide. This width is wholly

inadequate to the service of navigation, directly below the lock.

The expert report does not provide for a waiting basin below the locks, and their 500-ft. waterway is insufficient for the reception of ships without one. A very large waiting basin is assuredly indispensable to the service of ships. The ex-chief engineer points out this omission on the part of the experts. He writes—(letter of Jan. 26, 1906, p. 20):

"I believe, however, that the construction of a large basin or inland harbor at or near Mindi, or at a convenient location which exists below the Gatun dam, such basin to be supplied with coaling and other proper outfitting facilities, will be found advisable; the material excavated in the construction of such a basin to be used in the construction of the Gatun dam."

This widening is needed near the locks. Docks will be a mile or more from the lower margin of the Gatun dam. They will be thus beyond the limits of direct hydraulic dredge-pipe distribution and lift, to the height required for utilizing the basin material in the dam. This basin will have to be excavated last, after the channel reaches its location; otherwise a special channel half a mile long must be dug to it eastwardly from the old canal, in order to give the floating plant water access to the area to be dredged. Such a canal will likewise cross and interfere with the Panama Railroad.

The material dug from this widening must be therefore transported in the same fashion as the spoil in all the rest of the approach to the Gatun locks, viz., by barges. They must steam or be towed back down the newly dug channel and then up the old canal or through an expensive and inconvenient cross channel. This has not been estimated either. Some of the material might be pumped twice to get it to the foot of the dam, first into the old canal bed and then into the lowest parts of the structure; but the quantity of direct excavation and distribution that can be done by such a method is limited to a relatively unimportant amount by the great length of the dam and the height to which the material must be hydraulically lifted.

Pump Locations.—The material excavated by whatever process from the Mindi-Gatun section comes, much of it, in the condition of large, hard masses, as was said, to the foot of the dam. These chunks are intermixed with material, "soap-

stone" or "whetstone," in quality a close-grained, refractory clay-rock. Assume, now, however (but, be it clearly understood, assuming it for argument only), that the stuff were mechanically prepared for the dam, we have to consider next where pumps are to be located, and, further, their relation to the work they have to do, namely, that of lifting this prepared material through heights of fifty and eighty feet—for the government's Gatun dam is to be 135 ft. high, unless it be decapitated.

The macerating and pumping stations (in numbers, since 5,000,000 cu. yds. are expected to be handled per annum)

BATES' HYDRAULIC DREDGE. NEW YORK BARGE CANAL.

must be located below the center of the east and west sections of the dam. For the east section the canal affords access; for the west section barges must come up to the junction of the old canal and the Chagres, opposite Gatun, then go down the Chagres, then up the old west division, a distance of two miles. This old bed and the diversion would have to be made navigable at high expense, for they

are not now nearly deep enough for the service demanded by the barges and tugs. Next we are met with the fact that nowhere ever yet has material been pumped to a distance of over 2,000 ft. and lifted higher than 35 ft. Beyond that combined distance and lift everything is experiment. Theoretically, centrifugal pumps may be compounded or siamesed, but no one in the whole wide dredging world has had the experience or the evidence or the demonstration which would give any warrant for resting the execution and the estimated time and money for this dam on the basis put forward by the experts and approved by the commission. In his testimony, the chief engineer (p. 900) supports this method of construction for the Gatun dam. So much the worse. Nowhere can an instance of it be cited; nowhere can a satisfying demonstration be named. It is nothing short of fatuous to thus lightly rest this national enterprise upon untried methods, vastly beyond the range of experience and past success.

In regard to the construction of the central feature of the 85-ft. project—the Gatun dam—there are yet to be detailed two points of so much importance that we gather together the strings of its prescribed process.

It has been seen that the government has now authoritatively and with emphasis denied its intention of using the mud silt of Limon bay for the dam, as was proposed by the minority experts. But it still maintains its purpose and its ability to utilize the 11,000,000 cu. yds. between Mindi and Gatun along the newer line which it has adopted—a channel which was shown to be again different from that of its experts' recommendation. This line bears from the ocean to the Limon shore, and then, admirably straight, past Jaramillo hill across the "Swamp of Quicksands" to the foot of the locks. The excavation is avowed to contain one-third clay-rock—3,667,000 cu. yds.—all of which is under water.

As showing the difficulty of handling this clay-rock, the following is convincing:

The chief engineer's letter, dated Culebra, January 12, 1907, has now been printed by the Senate committee. It contains this significant sentence in regard to excavating indurated clay:

"At Gatun the test holes which we are putting down 6 by 8 ft. we are hardly able to excavate more than one

foot per day of ten hours. And all of them have to be drilled and blasted."

"Unit Price."—It still clings notwithstanding to the "unit price" of 70 cents for excavating and barging this to the dam, up the silt-choked old canal and through the crooked silt-choked channels of the old river and diversion to the dam site. The preparation and maintenance of this canal and these channels for the service of barges day and night for years, has, it was shown, never been reckoned, and they run amid the worst mosquito and fever laden swamps of the whole isthmus. It is impossible to eradicate the condition of these morasses in any way save by submerging them under a lake. Another third of the material is of light top-muck and sand, intermixed with roots and rank growths, vexatious to dredge or to re-handle. This leaves one-third of the excavation, which must needs be put into barges by bucket dredges, as the simplifying and cost-reducing hydraulic machines could not deposit into such small receptacles; the spoil will not have room to settle in the hoppers, and would flow over the sides of the barge. So we have 3,667,000 cubic yards of fair dam-making material and 3,667,000 cubic yards of clay-rock and miles of canals to open and to be kept open for navigation. Such is the dredged material which is to be incorporated into a dam that for size and weight is the most monstrous construction ever attempted by man.

Proportions.—Visualize this dam! It is 8,640 ft. from valley rim to valley rim, and half a mile wide. Its crest is at the height of the Brooklyn bridge above East river; its length extends from the Brooklyn abutment across the East river and across Manhattan Island and across the Hudson river to Jersey City. The East and North rivers correspond to the two channels around the island in Gatun Gap. Through these channels was discharged in 1879 the greatest known flood of the Chagres river, upward of 147,800 cu. ft. per second (Bohio discharge plus 77%), or including the run-off from Obispo to Pedro Miguel, roundly 250,000 cu. ft. a second.

The Gatun dam is to enjoy magnificent proportions surely. Its volume includes 21,200,000 cu. yds. of earth and rock.

The rock for this mammoth construction, though costly of distribution by train, is attainable. The bank protection can be supplied despite the manifold difficulties that attach

to selecting from the saturated and slackening, sliding clays and volcanic melange of Culebra, millions of tons of firm clean non-disintegrating stone. But the great mass of the "low mountain range" is another matter, and it is this earth fill for the interior which has been criticised in the preceding studies.

It will be recalled that the subterraneous conditions under this huge dam were shown to be artesian. Hydrostatic pressure upon the permeable layers lifted water in the Gorge bores from 8 to 17 ft. above the river.

A first point of interest at this stage is that the minority experts of the International Board and the Commission, all except one, recommended originally this dam at Gatun because they conjectured that the subterranean waters could be cut off. The following is their language on page 72 of the board report:

"It will be feasible to begin at once the construction of one of the earth embankments, permitting the water to flow through the channel or channels at the site of the other embankment. It will also be feasible to begin at once the construction of the diversion channel, utilizing the material excavated in the embankments of the dam.

"In the construction of the dam it is proposed to remove all trees, stumps and roots from its site and to excavate the surface material to such an extent that the impervious material of the embankment will come in direct contact with the impervious clayey material which is found nearly everywhere in this region; also to do any other work required to cut off the flow through any pervious material which further investigations may disclose."

Dam Over Permeable Strata.—Here, then, is the clear, definite direction of procedure to give a warrant for establishing a massive dam over permeable, water-bearing strata. Consider the situation revealed by that pregnant sentence, "also to do any other work required to cut off the flow through any pervious material which further investigation may disclose."

This Gatun dam was proposed by the five experts of the International Board and supported by the Commission and Secretary of War, therefore, on one or other of two bases. Either they had not sufficient borings to reveal the real subterranean conditions and did not know them, or they

did have evidence and proposed again the impossible in incorporating the direction "to do any work required to cut off the flow through any pervious materials." There was either ignorance of the underground conditions or a recommendation of the impossible. The Maltby profile of November 3, 1905, being called for by the Senate committee, it was no longer possible to suppress a knowledge of the real subterranean conditions and, being hard pressed, these engineers flitted from defense of one of these hypotheses to defense of the other. First they announced that the subterranean conditions would not beget seepage—seepage, which was the merest corollary to the real problem involved—i. e., the foundations themselves over such artesian and permeable strata. Then they fluttered to the other tack, saying that perchance they might curtain or grout against the underflow. The utter impossibility of cutting off this slow resistless underground river here has been shown. So the rash and partisan adoption leaves an interesting question as to how much the experts' responsibilities are really enlisted in their dam, whose underflow must unquestionably remain despite their deliberated stipulation for its entire barring.

Seven Borings in 160 Acres.—The Board and Commission and the Secretary of War had before them the Maltby artesian map of November 3, 1905. From it their plate for the report was prepared, but the artesian record was omitted. There have been no boring profiles made public since March, 1906, on the dam site. This Maltby profile, from the field notes, showed the bores—seven artesian in a total of eight in different strata, varying from 31 to 268 ft. in depth. These seven were into geologic gorges totaling over half a mile across. The dam is likewise half a mile wide. Hence, there were then seven small, hastily driven bores in a space including more than 160 acres.

Although it appears from a cable of the late chief engineer that subsequent to the last reported borings in Spillway hill some more bores have been sunk in the valley and some presumably into the area over the gorges, no profile was sent to the Senate committee on their late request, save this same blue print "No. 3" (p. 3211) of the Maltby profile of 1905, which it is here seen shows seven holes artesian.

CURTAINING THE UNDERFLOW.

Above, then, is the direct pronouncement of the first vital preliminary step for the Gatun dam. They are going to "cut the flow" in these gorges, one 204 and the other 268 feet deep! They do not tell how it is to be done, and, of course, as usual, there is no estimate for it. The Bohio dam was discarded because there was no way to curtain the underflow in its 168-ft. gorge. These Gatun chasms are a hundred feet deeper. Yet this great integral central feature of the government project is founded upon the positive stipulation that the flow through these permeable strata should be first "cut off." They are going by some marvelous process to curtain and stop the flow of the present underground river and the greater flow that must be produced by the high and extended lake. All the commission but one, all the minority experts, the Secretary of War, formally indorsed this report, this plan, this program—this "cutting off" absurdity. Are they going to build the dam and never ask, and never decide, and never know how the foundations are to be safeguarded as they stipulated? After this precise proviso by the precise experts who are going to select the precise location of each lock, is the dam going to be adventured without any "cutting off?"

Although there existed this authoritative and provident provision, the hoop that bound the expert and commission fagots, nothing has been done toward solving the new enigma.

It comes to this again—either the underflow is to be "cut off" in some magic way unrevealed or the experts' design has once again been thrown out in this most vital feature of the whole Gatun dam. According to the October issues of the "Canal Record" the "soft" ground is to be stripped off and the filling is to begin. Who, then, is planning the government canal? It is being held up before the country as strongly intrenched in the judgment of both bodies—the expert minority, the commission itself and the late chief engineer. It is seen, however, that in almost every detail thus far examined the experts have been thrown overboard and the commission's earlier adoption and avowals have been likewise repudiated with them, and though one by one the engineers depart, yet Panama canal designs, different and contradictory, keep coming forth regardless. Whence comes now this new song, it

is not necessary to "cut off the flow through any previous material which further investigations may disclose?" Who fathers it? And what is its investiture of authority? The dam is a low mountain range. Yes. But water can move such mountains. Since the experts conditioned their approval of their high Gatun dam on that sentence, if the flow cannot be "cut off,"—ipso facto—it is all up, so far as their "expert" advice is concerned. Does it not seem passing strange that the authorities should plow on and send the selfsame men who signed that conditioning sentence to locate the structures definitely? And this though the whole experting is nullified by the certainty that no way exists to get a curtain to the bedrock for "cutting off" the flow in the many pervious strata in the great gorges under hydrostatic pressure.

It has been a private conviction that the government, despite its sanguine support of its proposed method of dam construction, would never put it to the peril of a test. They would purpose, of course, dropping quite unobserved the impractical hydraulic proposition for constructing the high levels of their Great Gatun dam. They would abandon it in this way that the branding of their expert's engineering and their own past engineering might go unnoted. They had dropped already in the same manner the international impractical five million dollar breakwaters and the international reef-ridden Pacific approach. They repudiated in January, 1907, the experts' mud-silt for the heart of the dam and "cutters" for the Mindi-Gatun rock excavation. They had also superseded the expert alignment at both canal termini and in the Mindi-Gatun section. The hydraulic method in principle for the dam has, however, been corroborated. But all the time that the fiction of this system for using 18,000,000 cu. yds. of dredgings, all the time that this face of method has been defended, there have been seen quite other plans a-brewing.

After all the undoubting, aggressive defense of the prescribed program in the Senate committee and in both houses, there was a revolutionary sentence in the message of December 17, under "The Culebra" heading, "The dams will be composed of earth taken out of the cut." So and indeed! Here comes a proposed cutting of the Gatun knot. The authorities then have become convinced at last that the proposition for constructing the bulk of such a dam in such a place, from such dredgings, by such a process, was impractical?

Have the engineers remaining in 1906 cancelled the experts' experting and the commission's commissioning and told the executive that they must undertake the monster mountain in quite another way? What then is involved in the substituted Culebra car-fill method which the message thus briefly but distinctly substitutes?

The right hydraulic dredge system is a very cheap one where applicable. The cost of the Gatun dam was figured as was shown upon using its process for construction of the whole inner fill, and the yardage was vast. If now it is replaced by the rail method, and most of this yardage must be brought down from the Culebra cut, the time of execution must be very largely increased. It becomes a different proposition entirely, and the sooner this is fully realized and openly acknowledged the better. To keep on defending hydraulic dredge unit prices and an eight-year construction time when material is really to be brought down by rail from Culebra and be lifted every yard of 18 millions to the growing height of 100 or 135 ft. is unwise. It would take 400 twenty-ton cars every day for eleven years simply to bring down the material to the Gatun dam site. Lifting, wetting, puddling and other processes of building would still further lengthen the construction period. If, therefore, the brief message sentence is a herald, quite a new order must be faced, both in the money and in the time estimates for the Panama canal. There will be no eight-year completion and no 140 millions canal cost. The people must get ready for what the substitute method includes.

CANAL FEATURES IN MINDI-GATUN SECTION.

It will be recalled that the government scheme passes Mindi, carries a 500-ft. channel through the swamps and quicksands for several miles and arrives at the foot of the great triple flight. This lock flight and the Gatun dam are set between the low swamp reaches and the Summit lake.

The position of the summit-making dam and locks it was pointed out earlier must be adjusted to the needed transit capacity of the canal.

The canal must be able to lock through all the vessels which increasingly "shall be reasonably expected" to seek this gateway through the long future.

The lockage capacity is limited by the mean annual run-off tributary to the summit-level lake or reservoir. But this is not mathematically proportioned to the mean contribution, because the losses from flood wastage, percolation, infiltration, evaporation and gate leakage vary with each plan of canal.

The mean annual run-off is roundly as follows: If the summit lock is at

Obispo (Gamboa)	3164 cu. ft. per second
Bohio	4798 cu. ft. per second
Gatun	8480 cu. ft. per second
Mindi	8600 cu. ft. per second

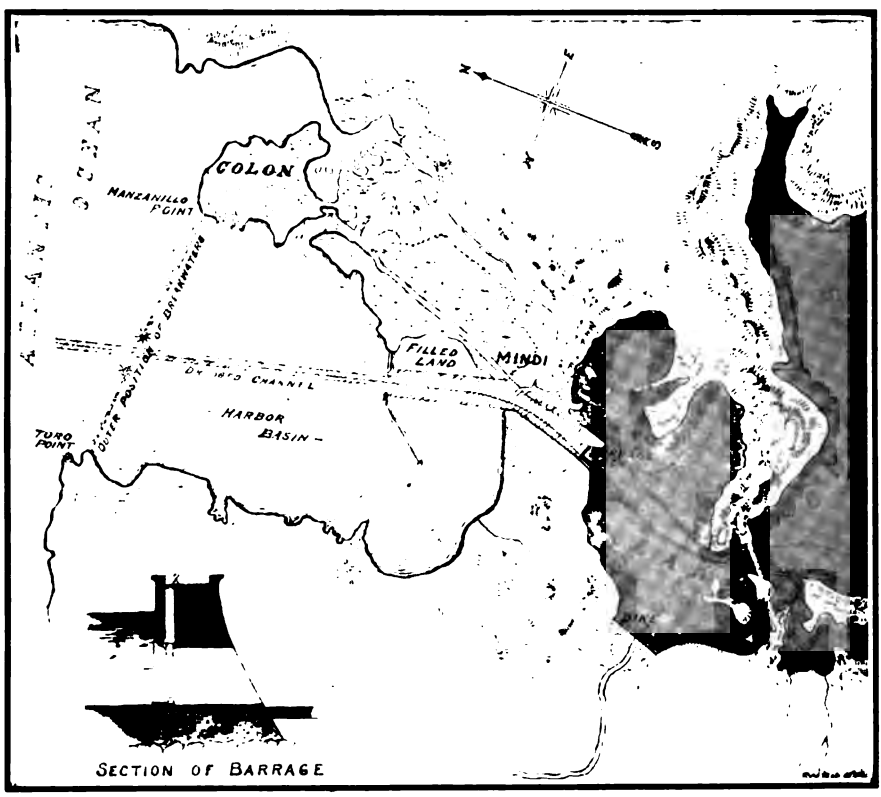
Canal's Transit Capacity.—When the demands of lockage, together with the losses from wastage (after reservoirs are full), percolation, leakage and evaporation in, for example, a summit level planned between Obispo and Pedro Miguel, reaches the 3164 cu. ft. per second of the mean annual run-off, the reservoir dams above Gamboa of whatsoever size they may be built cannot add anything to the transit capacity of the canal, because dams do not create rain, and rain is here the one source of water supply. It has been mathematically demonstrated that the transit capacity afforded by the 8480 cu. ft. per second passing Gatun is much over four times that given by the 4798 cu. ft. per second of Bohio and many more times that of the 3164 cu. ft. per second available at Gamboa.

It has been accepted as certainly fundamental that the Isthmian canal should be able to pass at least 50,000,000 tons per annum. This can be done only if the summit level be set at Mindi or Gatun, and it were idle blindness to propose sites at Bohio or at Obispo.

Accepting as the only worthy postulates, first that locks should not be placed in flight, and second, that the canal built should be adequate to future growth, it is seen that it is impracticable to have more than two locks on the Atlantic side—one at Mindi and the other at Gatun. It never has been and never will be practicable to make other dispositions.

No commission, French or American, no advisory board or congressional committee, no officials have ever squarely faced these incontrovertible facts.

There cannot be more than two locks when they are kept separate. If two locks are planned one must be at Gatun and the other at Mindi. If there be but one lock on the Atlantic approach to Culebra it must be at Gatun or at Mindi.



MINDI-GATUN SECTION WITH LAKE OVER SWAMP. THREE-LAKE PROJECT.

If at Gatun a dam be made on which there is only a 29-ft. head and but one separate lock, lifting from a lower lake at around 33.5 ft. to the Gatun summit lake at 62.5, then the existing perils and perplexities incident to the gigantic dam and the flight of Atlantic locks are resolved. It is seen that the situation reduces itself to this—the creation of a lower

lake at about 30 to 33.5 ft. The keys to the whole Atlantic end of the canal become therefore the two locations below Gatun for impounding structures—the reef of the Lower Chagres and Mindi.

Insures Certainty and Success.—At Mindi, where the hills divide the lower Chagres basin from Limon bay, there is a gap, and where the Chagres river pierces the range there is a long, narrow valley. By closing these two small breaks with a low dyke and a sluice barrage, together less than a mile and a third long, a very radical and revolutionary canal arrangement results. An invaluable lake is impounded which changes fundamentally all the dam heights and lock dispositions constituting the Atlantic section of the waterway. The facility is truly surprising, and the construction is almost the minimum possible, if this artificial lake is set at a low level. A glance at the plan will show how very narrow are the two gaps compared with that at Gatun. The easiness and safety of impounding so low a head of water give certainty and success to such a disposition.

This lake at not more than 33.5 ft. so simplifies and saves the whole eastern section of the canal that only upon the discovery of some insuperable natural obstacle should it have been evaded. The transcendentally vicious and evil combination of the great dam and the lock flight at Gatun should have turned the authorities to the most painstaking search for any attainable substitute. The inclusion of these two experiments and menaces would be justified only if they were the structures alone possible for securing a canal. No better way should have been passed till its last hope was quite exhausted.

Eliminates Greatest Dangers.—Consider what the creation of this lower Chagres lake will effect! First and chiefest it will enable the Gatun monstrosity, under an 85-ft. head, to be replaced by a low dam under a head of less than 30 ft., reducing the pressure to nearly one-third. The second greatest danger of the canal will be therein eliminated. Next, it will permit entrance to the upper Gatun lake by a single separate lock. The canal's foremost danger and defect—the tier here of three locks—will be also eliminated. A solution which at a stroke wipes out these two engineering barbarities should, by a government seeking supremely the canal's good, naturally have been thoroughly studied.

Note further what this low-level Lake Chagres would secure. The distance from Mindi to Gatun constitutes the first three miles of the canal proper. Millions of cubic yards of indurated clay, as well as other refractory material, as the last article brought out, must be excavated under the fever-laden "Swamp of Quicksands" here, to get the channel down to 41 ft. below sea-level, where it is located under the commissioner's designs. Further, the expert plan does not provide for a waiting basin below the locks, and their waterway is inadequate for the reception of ships without one.

When a lake is inserted reaching from Mindi to Gatun, it provides the ideal waiting basin, and there becomes almost no indurated clay to deal with. All this submerged indurated clay-rock excavation, the costliest digging on the whole canal, becomes unnecessary. The very little dredging indeed which remains to be done is in the light upper silt, not in the lower rock-clay. The French channel is already cut through here to the depth of 20 ft. Add to this a lake depth of 33.5, and a deep channel will exist practically all the way as soon as the low dykes are built. The clay is generally 20 or more feet below the swamp, so it would lie 50 or more feet below the lake surface at 33.5 ft. above sea level. As the building of the low dykes would require but around six months, the canal to Gatun (except as to the lock) could be available after this brief interval from the starting of proper plants. It gives a long stretch of lake where the morasses reigned before. This section, which under the government plan must remain for all time a fever-laden, mosquito-ridden, sweltering, poisonous passage, through the "Swamp of the Quicksands," becomes the healthful open surface of a pure, clean lake.

Other Advantages Gained.—In addition to the other advantages, the Mindi dyke impounding a low level Lake Chagres, entered by the canal's first lock here, would also establish, as was earlier shown, the site for the right terminal city. From any Panama map can be observed that to begin at Mindi makes transit in the canal three and a half miles shorter than if Colon be the terminus. Assuredly captains of large ships will prefer to pass through the canal in daylight. It is admitted that under the minority's design thirteen hours at least are consumed in traversing the waterway. Is it not better for this reason to dispatch the ship

from near Mindi rather than from Colon, three and a half useless miles away?

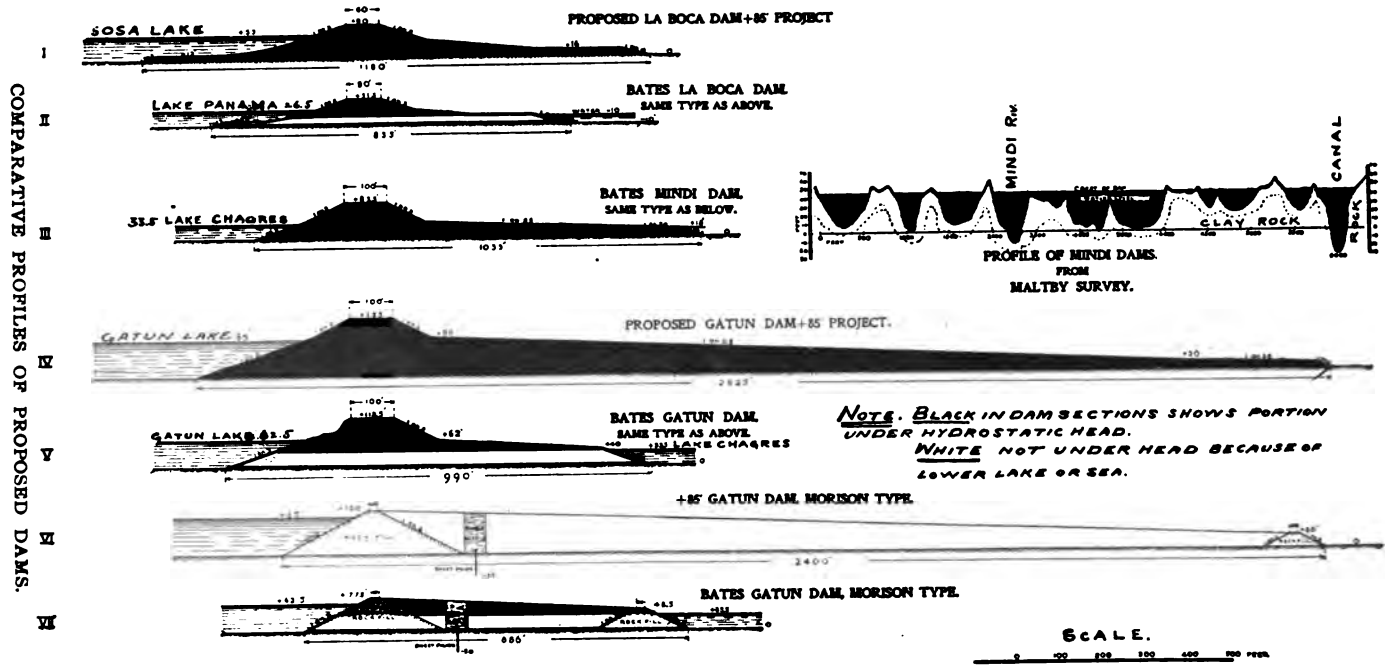
It means other technical gains. It enables the net head system on dams to be introduced—one with the very greatest possibilities of benefit. Intervening a lower lake between Mindi and Gatun gives 30 to 33.5 ft. of pressure on the lower side of a Gatun dam. At once the pressure against the upper side is compensated by this much and the mass needed in construction is diminished accordingly.

If next the lake above Gatun be set at only 62.5 ft., the pressure on a dam here becomes that due to the difference between 62.5 ft. at its upper side and 33.5 ft. on its lower side, or 29 ft. Such pressure requires only a small dam. It makes at once a very different proposition from the pressure of 85-ft. upon the very large dam which this height of water entails.

Gatun then would have a small dam under low head. But the Gatun site would be used at all only in event of creating a four-lock canal. In the adoption of a four-lock canal the Reef and the Mindi sites would be also used. In a two-lock canal the Reef and Mindi sites alone would be used. Both of these are rock at or close to the surface. Here nature has herself cut off the flow of the underground waters through the previous strata which exist everywhere else in the valley of the Chagres. The sea level had one lock.

Every Dam Upon the Rock.—There is a level whereat, it will be recalled, a two-lock canal is as cheap as a four-lock canal. In it every dam is upon the rock. In a four-lock canal one dam—that at Gatun—must be upon alluvial foundations, and because of the permeable strata in the gorges it must have a low head. The subsurface waters must be curtained somewhere, and this is only possible at the Reef and Mindi and by means of a lower or third lake. This the Government project lacks.

The rock foundations and the conditions are all so supremely good at Mindi and the announced Reef, and Jaramillo Hill is so sufficient that one can plan this lake level to fit one lock or two locks or three locks or even more locks, perhaps. It would not be here the question of right foundations, but a question of the wrong and vicious principle, in installing two or more locks in flight, when such is not imperative. The writer


COMPARATIVE PROFILES OF PROPOSED DAMS.
I
II
III
IV
V
VI
VII
SOSA LAKE
PROPOSED LA BOCA DAM+85' PROJECT
LAKE PANAMA +6.5
BATES LA BOCA DAM.
SAME TYPE AS ABOVE.
33.5' LAKE CHAGRES
BATES MINDI DAM.
SAME TYPE AS BELOW.
MINDI Riv.
CANAL
CLAY ROCK
ROCK
PROFILE OF MINDI DAMS.
FROM
MALTBY SURVEY.
GATUN LAKE
PROPOSED GATUN DAM+85' PROJECT.
GATUN LAKE +85
BATES GATUN DAM.
SAME TYPE AS ABOVE.
IN LAKE CHAGRES
NOTE. BLACK IN DAM SECTIONS SHOWS PORTION UNDER HYDROSTATIC HEAD.
WHITE NOT UNDER HEAD BECAUSE OF LOWER LAKE OR SEA.
+85' GATUN DAM, MORISON TYPE.
BATES GATUN DAM, MORISON TYPE.
SCALE.

has strongly deplored lock fights from the standpoint of safety to ships and safety to the canal. Vessel sizes are increasing steadily. The ships of the future will be larger, heavier and more difficult to safeguard and more dependent upon the right protection. So the whole basic idea of locks in flight for great ships is wrong. But the capacity of the Mindi sites for lock flights is recognized. The Gatun three may be moved bodily down to Mindi. That this site should not be appropriated for "M. Kleitz," like so much else, and without the amenities, the copyright for all permutations was put on record.

Perfect Harbor Combination.—The introduction of this lake over the "Swamp of the Quicksands" also makes available, as no other arrangement whatsoever can, the greatest and most perfect Atlantic harbor combination. The new city on the Mindi Hills would have in front an outer salt harbor on Limon Bay, and behind an inner fresh water harbor on Lake Chagres. Navies could ride in the lake absolutely protected by the encircling hills from the fierce "northers" which sweep Colon and compel every vessel in the harbor to take to sea. Dry docks, depots and wharves would be located here, where not a wave would disturb their service.

Again there is an advantage not technical, which must appeal to Americans nevertheless. Colon is a foreign city. While America has certain rights there, a foreign flag waves, a foreign council rules, foreign judges mete out sentences to our citizens. The new city of the Mindi Hills would be upon American territory. The superb harbor which Lake Chagres makes possible would be our own. The inward position would render it unreachable by hostile cannon so long as the forts at Toro and Manzanillo Points—four miles seaward—were not reduced. Behind Jaramillo Hill, on Lake Chagres, shipping or war vessels would be in the safest position that could almost be conceived.

Mindi and the Reefs.—One would naturally suppose that a chance to gain at a stroke all the great advantages at Mindi would have secured for the opportunity and the sites a most thorough and conscientious consideration and examination.

It was apparent that very many radical betterments were involved in the Mindi site. First, it gave the right high, healthy and attractive environment on the Mindi Hills for

a Terminal City. Second, it set this Terminal City beside a single Terminal Lock not six miles away from it and necessitating two stops. Third, it gave a Lake to Gatun instead of a channel through a disease-breeding, mosquito-ridden morass. Fourth, it gave a superb inner fresh water harbor. Fifth, it enabled the net head system to lower the pressure and risk on a Gatun Dam. Sixth, it enabled the mass of the Gatun Dam to be proportionately diminished. Seventh, it supplied the ideal waiting basin below a Gatun Lock. Eighth, it eliminated the indurated clayrock excavation. Ninth, it submerged the deadliest swamps on the Isthmus, substituting a lake of pure water hence it sanitized fundamentally by right engineering. Tenth, it enabled the Canal to cut out the vicious lock tier system and to substitute single separate safe locks. Eleventh, it secured room at lock sites for right and adequate safety devices. Twelfth, it saved, at very conservative figures, over fifteen millions of dollars. Thirteenth, it cut down the land width of the Isthmus in six months to sixteen miles after plant was ready. Fourteenth, it dispensed with the large labor force and rock plant demanded in the four-mile land excavation through this refactory section. Fifteenth, it enabled water plant to come to the assistance of the land plant in the great work of excavating the Central Mass. Through this it both cut the great cost of excavation in the dry and it diminished the great delay in time to which the ruling features of the 85-foot scheme must hold the Canal's opening.

All these inherent possibilities were pointed out and the corroborating official data, as the President's order had directed, were due from the Secretary of War.

What was done?

Here is the record:

Mindi Gap and Range and Chagres River Below Gatun.—The Advisory Board Report refers in these terms to the first land features encountered beyond Limon Bay (pp. 25 and 26):

"It early became apparent that additional information was desirable relating particularly to the possible dam and lock sites at Mindi, Gatun and in the vicinity of La Boca. The Board requested the Isthmian Canal Commission to have further examinations made, as follows:

"1. On the Mindi line the examination to be topographic with respect to the ridge line to the east of Mindi through to Jaramillo Hill, thence to the shores of Limon Bay, in order to develop any low passes communicating with Chagres River, and over the Jaramillo Hill near the high ridge line of the Chagres River and across the same, connecting with the high land to the west of the Chagres. This examination to be carried up to elevation 50."

With reference to the Mindi location, Mr. F. B. Maltby, division engineer, reported:

TOPOGRAPHY AT ATLANTIC TERMINUS.

"On the west side of the canal the high ground is continuous from the Jaramillo Hill to the Chagres River. * * * From a personal examination I am quite sure that a point can be found in this vicinity where the distance across the Chagres Valley to an elevation of at least 50 ft. is no more than 3,000 ft." The distance across the valley at Gatun, it will be recalled, is 4,675 ft. between the 50-ft. contours.

"I think it more than probable that surveys would develop a possible crossing of a shorter length. On the east

side of the diversion at Mindi the hills are simply isolated knolls for a distance of half a mile east from the diversion channel. From these is a continuous ridge, which is very much broken in elevation, but in which there is no point which has an elevation of less than about 40 ft." * *

"It therefore seems possible that should such a project be contemplated, a dam might be built from the Jaramillo Hills across the canal, connecting the various hills as far as the east diversion opposite Mindi. From there, for a distance of a half a mile, it is probable that a dam, having a base at an elevation of only five or six feet above the sea, would require construction for half the distance. In addition to this there would be a dam across the Chagres River of about 3,000 ft. in length.

What the Asterisks Represent.—In the Maltby report the asterisks represent the following sentences suppressed for obvious reasons:

(1) "This (Jaramillo) is the first hill on the right that we saw when we went down the Chagres River."

(2) "I have not had the time to prepare any maps showing this work, and, in fact, after what we have done is plotted it will show very little on a map, as it is simply a single line run irreguarly, keeping at all times on the high ground, where such ground existed."

There is also the following unpublished letter:

Isthmian Canal Commission,
Department of Engineering and Construction. Office of Division Engineer,
Cristobal, Oct. 26, 1905.

General George W. Davis, Chairman Consulting Board of Engineers, Washington, D. C.:

Sir—I have the honor to inclose herewith blueprint of a map, scale 1 : 3,000, from the vicinity of Mindi River to Gatun.

This map shows the results of some recent investigations made concerning the possibility of a dam at Mindi and a possible relocation of the Panama Railroad to mount the elevation which would be created by the construction of the Gatun Dam.

There is also a profile showing the elevation of the ground along the line B, or from the west side of the canal at Jaramillo Hill to continuous high ground on the east.

Also a profile along line A, showing a possible relocation of the Panama Railroad.

As stated in my letter of October 21, the Jaramillo Hill is continuous to the Chagres Valley, and the crossing of the Chagres Valley proper can be had *with a length of not over 3,000 ft.* Very respectfully,

F. B. Maltby, Division Engineer.

Copy to Chief Engineer.

The report details, page 124:

"Thursday, October 5, the members of the Board took train at 8 a. m., proceeded to Mindi, where they disembarked and climbed the hills to the eastward of the canal overlooking the country, and examined possible sites for locks and dams; returned to the train and proceeded to Gatun, where the hills in that vicinity were climbed and a view of the country obtained.

"Messrs. Davis, Abbot, and Quellennac, accompanied by General Ernst, went by train to Gatun, thence by launch to the mouth of the Chagres River, thence by sea to Limon Bay, skirting the west and south shores of the bay to the mouth of the Mindi; entering the same, proceeded through the canal to Gatun, and, returning over the same route, passed out again into the bay and returned to the ship.

"The weather during the first five days of the stay of the Board on the Isthmus was exceptionally pleasant, thus facilitating the excursions which have been recorded. On Monday (the day of launch excursion) it commenced to rain, and the rains continued remittingly, but in large volume, until the Board left the Isthmus on Wednesday evening. The Board thus had an opportunity to observe the country under favorable conditions and also when the flow of the rivers was very much increased by the heavy rainfall."

An engineer detailed to examine the Mindi site for a terminal dam therefore reported its width less and its configuration far more favorable than even the previous data had shown.

The Advisory Board made the cursory examinations which its report recounts. At its request Mr. Maltby was assigned to make a simple reconnaissance without borings east and west from Jaramillo Hill and across the Chagres. Those on the Mindi dam site eastward from Jaramillo Hill indicate that indurated clay rock is comparatively close to the surface all the short way across. There is no Bohio or Gatun geologic gorge at the Mindi Gap, and nothing

to prevent a masonry dam or a perfectly tight rock-and-earth-fill dam here, or the rock-founded under-sluice barrage, as projected by the writer. He also found that to dyke the Chagres and make the 33.5 ft. lake there was needed one only 3,000 ft. long.

Assumptions Wrong.—Mindi is the place where the French first encountered rock. The cliff rises 70 ft. above the canal. Numerous borings have been made across the site here, so we know that clay rock is closer to the surface at Mindi than at any other dam site on the whole Isthmus, save at the Chagres Reef.

Across the Chagres Mr. Maltby finds the distance from hill to hill at the 50-ft. contour, but 3,000 ft. or "less most probably." At Gatun it is 1,675 ft. more, or 4,675 ft. between these same 50-ft. contours. There are four miles of the Chagres below Gatun practically unexplored as to dam sites. There are several places narrower than at Gatun between spurs of rock. Had any one the right to conclude that there were no dam-sites in these four miles of river coursing among jumbled hills and spurs on either side, which are undoubtedly the latest geological formations on the Isthmus? And just here the Reef disproves all their assumptions and shows that they were entirely and fundamentally wrong. This is no new phenomenon. The treasures of Cripple Creek were strolled over by herders for fifty years before their time had come.

Surely at Mindi, and on the Lower Chagres, if anywhere at all on the Isthmus, there was an imperious and impressive duty for thorough and exhaustive study and the most zealous effort to secure its betterments. What is to be said, therefore, of an ignoring of this location without a single boring and the collection of almost no official information whatsoever to present the truth, though the executive order for data had been so precise?

From the record has been seen all that has been done by the Board, Commission or Secretary to support the facts regarding the Mindi lock-and-barrage and the Chagres Gap sites.

Six Strenuous Minutes.—During the week of visit to the Isthmus the Board alighted from their private train and glanced at the Mindi site from a point over half a mile distant. Subsequently three members set out in a launch from Gatun for the mouth of the Chagres River. But a blinding rain came on, a tropic rain which makes every-

thing a blur. The launch passed swiftly down between the hills to the sea, around to Limon Bay and up the Chagres River debouchment and old Canal to Gatun, then back again through the canal to the ship, never stopping. Allowing the launch the speed of six miles an hour, one may reckon that they allotted to both crucial sites six minutes! Could any engineering be less conscientious or profound? This inspection and the ordering of a meagre land reconnaissance, whose very favorable reports were absolutely neglected, sum up the investigation of the most pregnant and farreaching opportunity on the Isthmus.

No detailed examination was made, nor even an instrumental survey, let alone a boring. With such superficiality regarding a momentous interest of this the greatest public work of all history, which a trusting nation believed was receiving the highest intelligence and devotion, the Mindi location with the full cognizance of the Secretary of War was abandoned. It gave promise of changing the Panama Canal from a thing of monstrous experiments and expenses to a national waterway, safe for the commerce of a waiting world. But such evidence shows that these bodies of officials had gone to the Isthmus pro forma only to cement predeterminations.

There are very good data showing that the sites at Mindi and the Reef are not only practicable, but that they are the very best existing on the whole line for the low dams and the lock proposed.

That the nine knolls in the Mindi Gap are rock clay is proved by the French Canal and Diversion cuttings on each side. This geologic fact is borne out by all the collateral evidences and by borings privately made two years ago. A short way seaward from Mindi the French excavated a dry dock in the ordinary material there, which was indurated clay. This clay rock is very dense, indeed quite impervious. In face of the fierce tropic weathering it still stands in a clean slope and is being used by the Commission.

Better Site Than Gatun.—The Mindi Cut, by which the Chagres now partly discharges, is artifical; it was made by the French. A few feet below the surface the clay-rock was encountered, and it continued to the bottom of their Mindi rock cutting. Now the dam-and-lock site contem-

plated lies between two rock cuttings and other borings, at all of which the material was shown to be most favorable—better than at Gatun. For a lock and sluice barrage founded in easily reached solid indurated clay-rock the location has every assurance of proving the very best on the whole canal. Two weeks of surveying and boring by competent parties would have corroborated this officially to the world. Those in power whose Monstrous Dam on its artesian foundations is distrusted by every engineer in the country continue oblivous to Mindi and the Reef. Those in place, whose lock dispositions are distrusted even by themselves, and some of whose perilous flights are already being "rearranged" continue to neglect Mindi and the Reef. They stand under all it means to the country to thus systematically ignore the sites which would redeem their errors in the Atlantic end.

When it is recalled how safe on such rock foundations are such low dams as must withstand only a 33.5 foot head, the sufficiency, security and superiority of these dispositions for the first section of the Panama Canal become self-evident.

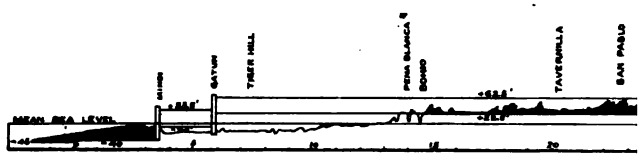
There are a succession of supreme and incontestible advantages made by simply creating a low dyke and the sluice discharge arrangements and setting the first lock at Mindi. These advantages are ruthlessly and wantonly thrown away by the custodians of America's opportunity.

Millions May Be Saved.—A low impounding structure and lock at Mindi are easily and cheaply possible; if constructed they will enable the head on the Gatun Dam to be reduced from 85 to 29 feet; one isolated Gatun lock can then be substituted for the three in perilous tier; the most unique, commodious and splendid harbor can be constructed here with fresh water within and salt water without; a healthy site for a new city on American soil will be furnished; millions of dollars will be saved by the elimination of excavation, and by diminishing the dam volume and cutting off the extra masonry needed to prop the lock flight; in six months after the provision of an adequate plant every swamp from Mindi to Tavernilla can be drowned under a saving lake, conserving lives and money; this can be effected without interference with the service of the railway; it will make a low net head Gatun Dam and the lock site

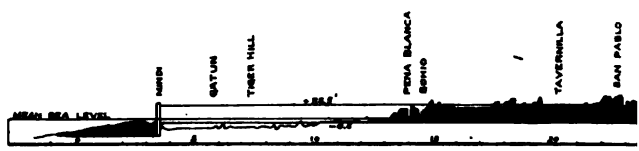
accessible to water communication and will bring at a stroke the construction of the Gatun Dam within the economical and mechanical limit of dredging and pumping methods.

If ever the general public can be induced to come at this Panama Canal matter as at any other, then the waterway shall begin to get another order of mind weighing and reasoning. It has been kept so enveloped in mystery and supposed incomprehensibility and expert nonsense that men will not think and judge as they do in untechnical fields.

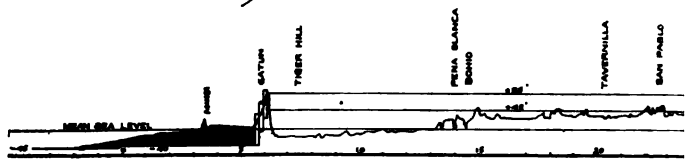
Surely there is nothing calling for engineering knowledge before a man can decide whether a channel with reefs or one without is a better approach; whether a city on a swamp six miles from the entrance lock or a city on a hill slope directly AT the first lock is best; whether a channel amid morasses or free navigation in a lake is best; whether a stairway of three dangerous locks, or a separate, simple lock is best; whether a huge dam or a small dam is best; whether a dam on pervious strata or a dam on rock is best; whether the expenditure of fifteen or more superfluous millions or its saving is best. All these fundamental Canal problems are questions not of technique, but of ordinary hard saving common sense. The sooner the plain business man begins to apply himself to the Panama Canal situation, the sooner will it be got away from its delirious engineering and its pernicious proposals for execution.



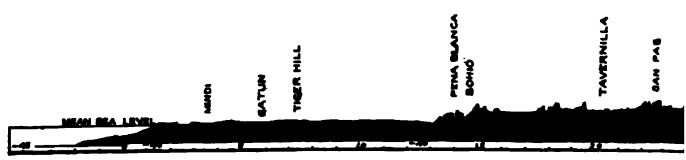
THREE LAKE FOU
62.5 FT. SUM



TWO LAKE TWO
33.5 FT. SUMM

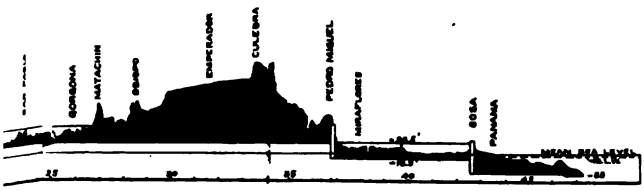


TWO LAKE SIX L
85 FT. SUMMI

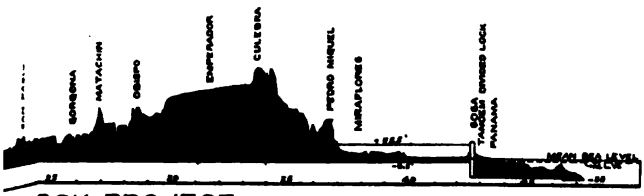


SEA LEVEL

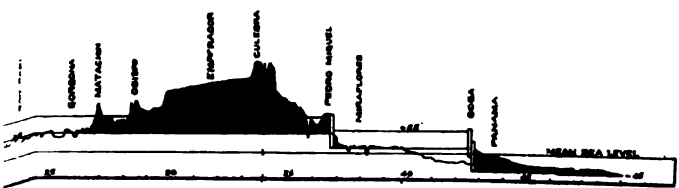
PROFILES COMPARING THE VARIOUS



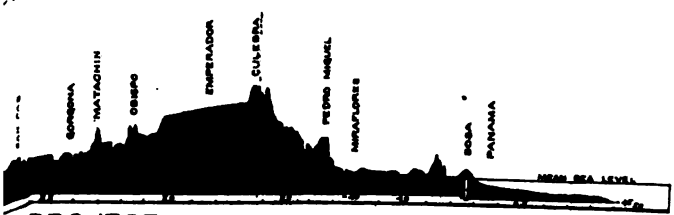
FOUR LOCK PROJECT
SUMMIT LEVEL.



TWO LOCK PROJECT.
SUMMIT LEVEL.



LOCK PROJECT.
SUMMIT LEVEL.



PROJECT.

PROJECTS PROPOSED FOR PANAMA.

CHAPTER XIV.

Lock Site Conditions at Gatun.

The three charactertistic features of the 85-ft. six-lock government plan are:

1. The gigantic Gatun Dam and the great Pacific Dams.

2. The massive flights of locks—two sets in duplicate of three each at Gatun and two duplicate sets of two each at Sosa.

3. The so-called safety devices as yet unknown and undetermined, which are to be auxiliary to the double gates in conserving Lake Gatun, the summit-level, in event of the carrying away of the lock gates.

The complete omission from the government plan of any provision for safety devices, or any allowance or estimate for the conservation of "Lake Sosa" in event the gates of the Pacific lock flight shall be destroyed, will be dealt with in due course.

It appears desirable to apply roundly some sort of measuring unit in order to convey a graphic idea of the masses involved in these structures of the 85-ft. lock-flight project. The Pyramid of Cheops is the "largest work of man's hands in the world." It is the only one remaining of the seven wonders. It originally contained 3,393,936 cu. yds. of stone brought from the Mokattam Hills just across the narrow Nile Valley.

The experts under the direction of the Secretary of War have given this government something to do at Panama. In terms of the Great Pyramid of Ghizeh the Gatun Dam is equal to six and four-tenths times its bulk; the material has to be brought many times as far and lifted to three-eighths of its height. The Pyramid was set upon a level plateau and it involved virtually no excavation.

The excavation for the lock flight is a cleft in a rocky hill, five-eighths of a mile long through clay-rock, blue clay, yellow clay, sand and gravel and continued in a pit, gashed through the "Swamp of the Quicksands" to reach the dipping rock. A pit 1,000 ft. long and dug to a depth of 50 to 60 ft. below the morass. (Official Section No. 9 will be presented in due course.) The volume of this lock excava-

tion is equal to one and one-tenth times that of the Pyramid and much of it is in clay-rock.

The concrete of the locks, their approaches and the spillway, approximate half the masonry that the pride of the Pharoahs heaped on the desert's verge, and much of the material for it must be brought over 2,000 miles. Similarly the Pacific Dams equal three and a half, the Sosa Lock Flight excavation and backfill two-thirds, and the Sosa-flight concretes over a quarter of such a pyramid.

The experts' estimate of cost at Gatun is very close to $24,000,000 and at Sosa $15,642,000, or nearly $40,000,000 altogether. The inadequacy of $40,000,000 to realize these structures has already been demonstrated.

The immense number of slaves who through the long reaches of years toiled at these Pyramids is generally known. But the number that shall be required on these American Pyramids is by the official announcement of last winter set at 37,500. When work shall be at its height 37,500 men to achieve this labor in eight years! The number in September, 1907, was over 41,000. "Canal Record," Oct. 16.

The days of the Titans have gone by.

The monstrous dam has been impeached—for the utterly insufficient data on which it was projected and indorsed; for the omission of the Maltby artesian data from the Minority and Commission Report; for the probable connection of the permeable strata in the gorges with the long Chagres pool half a mile below the dam and parallel with its foot; for its dangerous and indisputably artesian and permeable foundations; for the impracticability of its prescribed content and method of construction from dredgings; for the cost and time of its execution by the car fill method; for the inadequacy and danger of the spillway provisions; for the great weight of the crest mass inducing tendencies to dangerous, extensive and uneven settlement, at the verge of the two gorges.

The conditions existing under the Gatun Dam become of intimate concern to the flight of locks, first, because the two structures are continuous and contiguous, and second and chiefly, because there are permeable and blue clay strata under the upper lock and safety devices. The existence of permeable strata at such a crucial situation leads back to right foundations and the change in local conditions incident to impounding the 85-ft. Central Lake. At this juncture there

is incorporated, therefore, the warnings of Sir Charles Hawksley in his inaugural address in 1902, as President of that great and venerable body, the Institution ot Civil Engineers of Great Britain.

"I fully concur in the view expressed by Mr. Mansergh, with regard to reservoir dams, and also in the opinion (to which I had previously given expression) that it is essential that a masonry dam "should be founded on an unyielding base of sound rock"; and I am not likely to try the American method of placing a core of concrete in lieu of puddle in the center of an earth embankment, for it appears to me to be wrong in principle to attempt to support a practically inelastic material like concrete by an earth embankment, which must, from its very nature, be compressed when it becomes subjected to increased pressure.

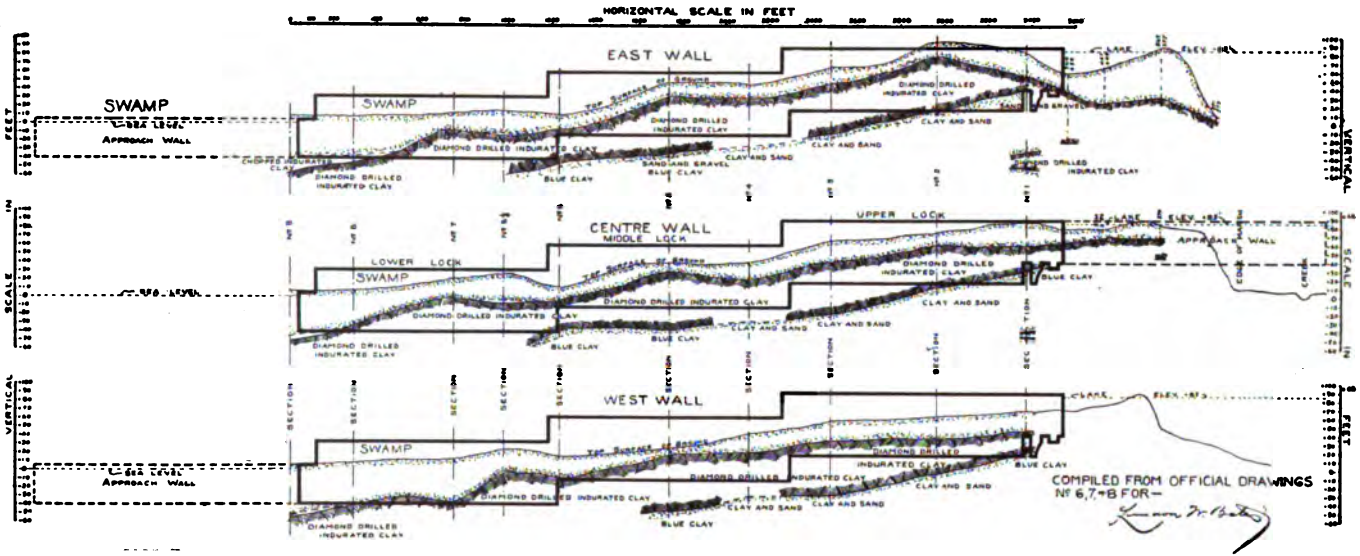
So far as the comparative safety of the two methods of construction is concerned, a masonry dam has the advantage over an earth dam in the event of its happening to lie in the track of a great waterrush. Some of the failures of earth dams have been due to the culpable neglect of those in charge of them having allowed the top of the embankment to settle below the level of the overflow weir.

In connection with the designing of earth dams too much stress cannot be laid upon the importance of making sufficient provision for the passage of flood waters during the construction of the embankment, or on the even greater importance of designing the overflow weirs and bywashes of ample capacity to carry off in safety the maximum floods, such as take place perhaps only once during a period of from 20 to 40 years, and which even in this country may exceed by several thousand times the minimum flow of the stream on which they occur."

The last extract is particularly pertinent because the Gatun spillway is inadequate and unsafe during the lock and dam construction period, and is even more unfitted to take care of maximum floods. Besides, it has in its converging toboggan slide, as was shown, all the elements of dam suicide and lock suspension.

This body of engineers, having intimate relations to provisions all over the world for the vast water-borne commerce and fleets of the greatest maritime nation, carry much weight in their warning.

There can be no flight of locks unless there be a huge dam, and vice versa. Before turning to an analysis of the flight, its mass of concretes, its enormous cost, there must be pointed out the facts bearing directly upon its foundations.



PROFILE—SECTION OF GROUND UNDER CENTRE OF EACH WALL OF PROPOSED LOCKS.

In coming to the consideration of the Gatun lock flight we begin with the high, imminent 85-ft. lake.

In the natural valley as it exists to-day at the Gatun gap, with the Chagres wending through devious channels to the sea and the slow-moving underground river bound for the same sea, there is one vital condition. Some of the permeable strata or bodies of sand and gravel are, as was related, under artesian stress showing unquestionable connection with the underground conduits of the upper valleys. This hydrostatic pressure brings the water to about seventeen feet above the river at sea level. There are bores which, only because they do not overflow the casing, are called "dry," but which, nevertheless, are sub-artesian, that is, the water is not under enough stress to be forced to the top, but it does rise partly or nearly to the top, demonstrating pervious material with equal certitude. This pervious material is very likely somewhere in connection with the bottom of the river bed, which usually accounts for the loss of pressure in such bores.

Would Greatly Increase Underground Flow.—Now is the time of minimum flow in the underground Chagres. From Gatun to the upper end of the Lake, beyond Gamboa, is a distance of some 30 miles and one may go as far up the Trinidad and Gatuncillo to reach the same elevation. In this distance the Chagres falls 85 ft. The stresses incident to the artesian strata are lessened by its long friction-absorbing course, but still their pressure remains enough to raise water seventeen feet above the river.

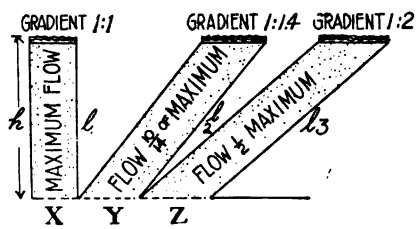
When this high lake shall be created, the flow through the pervious strata will be increased to the very maximum because the lake becomes just above and fronting the dam.

We quote from Page 158, Paper 136, U. S. Geological Survey, 1905:

"Inasmuch as the flow of ground water is nearly always caused by a difference in the case in which the ground water is free to move in a vertical direction, as in a perfectly underdrained sand-filter bed. The motion in this case is due to the weight of the water of saturation, and the flow is, of course, greater than would be the case if the water were obliged to flow in a direction inclined to the vertical instead of in the vertical direction, as supposed. These facts are illustrated in the accompanying illustration. The flow in the case of pressure gradient 1:1 forms a most convenient base for calculation, and it is frequently called, as suggested by Hazen, the maximum flow. The flow of any other gradient

is immediately calculable from the flow, being, of course, one one-hundredth of the maximum flow.

In these three cases (shown in Fig.), the upper portions of the soil columns are supposed to be supplied with water as fast as it can flow through the columns. The escape at X, Y, Z is supposed to be perfectly free. The head under which the flow takes place is h in each case, as shown at the left of the figure. The various lengths of the soil columns, l_1, l_2 and l_3, produce the gradients $h/l_1 = 1$; $h/l_2 = \frac{1}{1.4}$; and $h/l_3 = \frac{1}{2}$ respectively, with the resulting flows in proportion if the material in the various columns be the same."



FLOW OF WATER AT GRADIENTS.

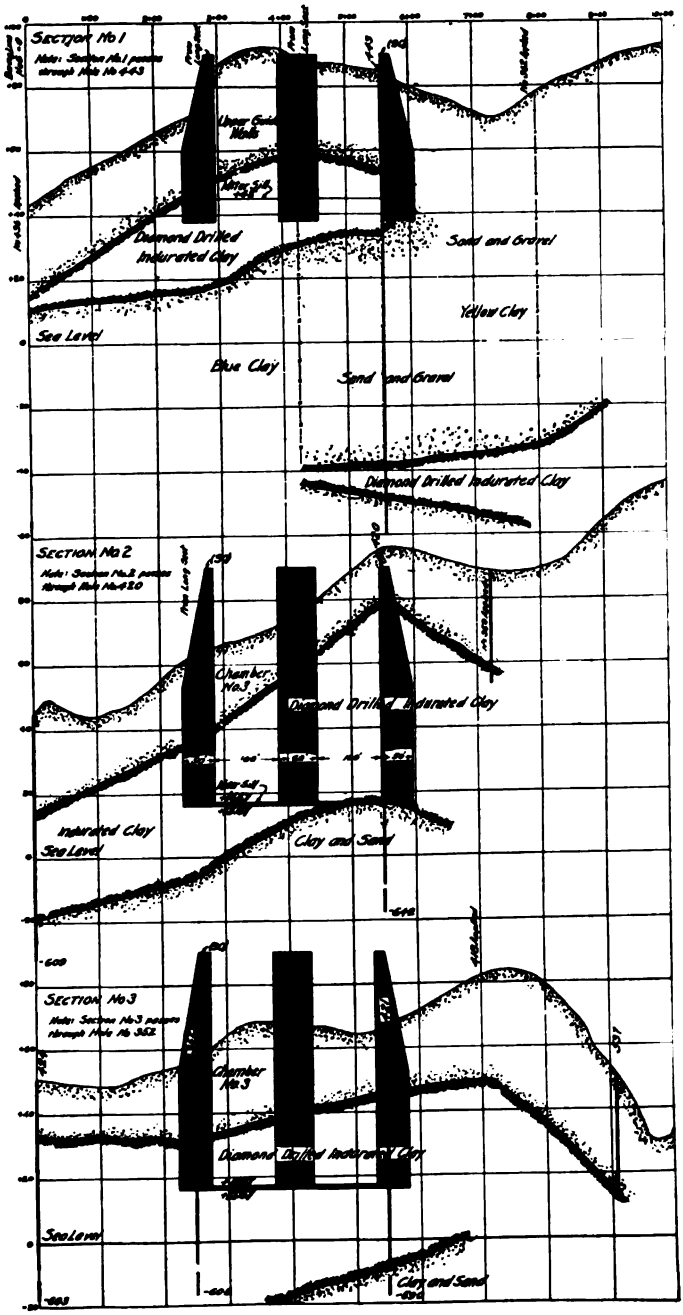
Borings Reveal Unsafe Foundation.—Not only are the pervious strata in the gorges under great imminent hydrostatic stress, but all the formation both sides of the spillway hill and at the east and west abutments on Locksite Hill and the Cerro Gatun.

It next becomes necessary to direct especial attention to the recorded character of the south geologic formation of Locksite Hill—"Locksite Cliff," say, as a distinguishing name.

The new borings any one may see by examining the official cross section presented herewith. No. 1 of this is the most southerly section through the upper lock of the flight. The borings show that under the lock foundation, under the thin blanket sheet of indurated clay rock, lies a stratum 70 to 80 ft. thick of material marked "sand and gravel, yellow clay; sand and gravel, blue clay."

This formation extends down to 40 ft. below sea level.

Underneath this thick and manifestly permeable formation is indicated another stratum of impervious clay rock some 10 ft. thick. The thick sand, gravel, yellow and blue clay strata form together, as it were, a huge sand-filled mouth of which spillway cliff seems the front on the new lake.



SECTIONS NOS. 1, 2 AND 3.

Next to the upper right guide wall, the permeable formation is shown as being 117 ft. thick.

The lake will front this entire permeable body and will beyond any peradventure saturate the mass beneath the upper lock-chamber and upper lock and safety devices if there were any room for such.

A pertinent resumé on the relations of clay, sand and gravel to dock and lock wall foundations is quoted from the latest English authority upon these constructions:

"Clay is a very uncertain material. It varies in volume, texture, and consistency. When thoroughly dry it is hard and friable; when saturated it becomes soft and viscous. Mixed with lime it forms a brittle compound known as marl. When the adulterant is sand the more tenacious product is called loam. Clays possess so many purely local attributes that little can be said of their efficiency as a class for foundation purposes beyond that they are usually satisfactory if properly protected. One variety of clay, the blue clay, however, possesses striking and dangerous characteristics, which call for special precautions. Several instances of failures in dock walls have occurred by reason of its treacherous nature. Apparently firm in itself, it often conceals planes of non-adhesion—surfaces in such a state of greasiness that they slide over one another with the greatest facility. These planes may be some distance below the foundation level, and involve the upper stratum of clay in the forward movement of the wall, as actually took place at the S. W. India Dock. A blue clay foundation has been responsible for the sliding dock walls at Southampton, Calcutta, Avonmouth and elsewhere. Nominally and generally bluish in color, the upper layers of this clay are sometimes yellow, due to the change of a protoxide of iron into a peroxide by the action of the air and moisture." Under the upper Gatun Lock there are blue and yellow clay both.

"Sand and gravel are usually firm and durable foundations, practically incompressible, but they must be confined laterally. They need protection from the action of currents. Very often beds or pockets of these substances are met with in the bowlder, drift or glacial clay."

Serious Conditions at Locksite.—It becomes evident from the foregoing that the impounding of the 85-ft. lake brings very interesting and serious conditions, not alone under the Gatun Dam, but at the upper lock site. The heavy concretes of the locks make the situation even more formidable than the earths of the dam. The permeable and treacherous clays must become saturated under hydrostatic pressure from a lake right at hand. One has, therefore, not only to consider the character of the material in Locksite Hill in its

present natural and well drained state, but the characteristics which will be developed when its permeable and clay strata become saturated and softened by the great lake.

The greater the head on this lake the greater the solicitude for the behavior of the underground Chagres and the behavior of the crucial strata of the Locksite Hill.

HOUSES RAISED READY FOR FILLING UNDERNEATH GALVESTON.

CHAPTER XV.

Lock Arrangement and Dimensions.

It is the purpose of this discussion to analyze as closely as the data permit this lock flight—as to its site, its foundation, its "safety appliances," its manœuvering devices, its mass, its design and its designers, its cost and time of construction and its relation to navigation.

The very momentous feature of permeable formations under the upper lock, and the Commission's arrangement of three locks in flight at Gatun have crystallized the greatest peril and engineering conflict of the Panama Canal. Here the point of dispute has not been the conditions which attach to all locks. That there is an element of uncertainty inherent in every structure of whatever nature is indisputable. Were it possible to eliminate locks entirely at the Isthmus such a disposition would be, in that one element, vastly superior. But nature in her disparity of tides on the two oceans and in the height of her Culebra, denied this possibility. The sea-level even was a lock canal. The conflict has not, therefore, been drawn in the compulsion of locks by isolated constructions which the physical conditions permitted, but by the tier of three, one above the other, with a lake of 85-ft. head at their summit—that is, by the Gatun lock flight.

Every engineer, indeed every man in the country, knows that sooner or later a lock accident must come at Panama. Just as in the city of New York the accumulated experience of the years suffices for statistics to forecast that approximately 20 per thousand of the population will die next year; just as the insurance companies are founded on the certainty of casualties in all things human; just as Lloyds, the underwriters, know that of the ships which go down to the sea some will never hail a port again, just so certainly do all men know that sooner or later a vessel shall hit one of the gates of the six Panama locks and an accident occur. There is no canal existing in all the world which has escaped mishaps. How and when and where we cannot foretell, but the fact is written in the stars.

Openly Courts Disaster.—The plan of the experts, the Commission and the Secretary of War for a ladder of three Gatun locks, in tier, one above the other, standing to-day as

the accredited administration project, is a plan which openly and unnecessarily courts disaster.

The most reliable gauge of the future is the past; the factor of chance at Panama is best estimated in relation to the actual records of other canals. There will be cited here the Soo, having probably the most fortunate history of any, and another, the Manchester, of average luck.

The Minority Report states of its best example, the Soo:

"The gates of the Poe lock have been struck three times and injured more or less; but they continued to support the summit level" (Lake Superior).

The majority of the International Board point out that, on account of several conditions which cannot obtain at Panama, the Soo's record is no valid criterion. It writes also in regard to these three collisions "resulting in each case in dangerous damage to these gates." On the Manchester canal four graver accidents have occurred since it was opened for traffic ten years ago.

The Majority Report summarizes in regard to mishaps: "Several of these accidents were so serious that disastrous consequences were escaped by a narrow margin only. It is practically certain that if the locks upon which these accidents took place had been of the dimensions and had controlled the great difference of level contemplated for the locks of the Panama Canal, not merely serious accidents, but disasters, would have followed in perhaps all these cases, throwing the whole canal out of operation for a period which cannot be estimated, and also wrecking the vessels in the path of the resulting flood, while the cost required to repair the damages is not within the limits of reasonable computation."

They denounced in the most unqualified terms these lock flights, "whose jeopardy is considered a very grave one," and which constitute the "very worst and most dangerous feature proposed for any canal."

"The three accidents at the St. Mary's Falls Canal occurred within nine years where there is only one lockage of about 20 ft. If six locks should be adopted in a plan for the Panama Canal, each having a lift of 30 ft. or more, as has been proposed in several projects, it would not be unreasonable, with an equal number of vessels, to look for six times the number of accidents in the same period of time, which would be at the rate of two per year. If groups of locks should be arranged in flights, as has also been proposed in some projects, the imminence of disastrous accidents would be greatly enhanced, as would be the amount of damage to the structures and to the vessels involved. Indeed, it is highly probable that the grave disaster of a great ocean steamship breaking through the gates below might be realized. It is the unqualified judgment of the Board that the United

States Government should not construct an inter-oceanic waterway to accommodate the commerce of the world exposed to hazards of this sort.

The conditions become even more serious when it is contemplated that the canal is to be used for strategic purposes and, therefore, for the inter-oceanic transit of vessels of war of the United States Navy. The difficulty of handling ironclads in the most favorable circumstances is notorious, while in the operations required for raising them in one series of locks and for dropping them down in another series, the difficulty would come so perilously near impracticability that, in the opinion of the Board, no scheme involving it should be accepted."

Such a clear, precise and complete denunciation of a government measure by a body of specialists called to select the best elements for a canal it would be hard to match in the annals of any profession.

But all this the Minority, Commission and Secretary of War receive in incredulity. They waive it aside. "The possibility that the ship will so completely wreck the first pair of gates as to continue its course to the second and seriously harm it is extremely small," they reply. It is not that they are foolhardy; they are just superior. A Commissioner voices the general attitude of boredom: "There are some people, you know, who are afraid to go up in an elevator."

The general subsurface conditions with permeable strata at the upper lock of the flight at Gatun, its safety devices and approaches have been briefly touched upon. The next point in natural order would be an examination of what the borings reveal regarding the very interesting characteristics of the foundations for the other locks. Before this can be treated, the length of lock site, must be decided, which in turn brings us to the preliminary study of the demands of existing and prospective commerce.

In coming to the consideration of lock lengths for Panama, the gauge of size had been established in general terms by the Spooner act. This was explicit in its stipulation that the canal must afford ample capacity for present and prospective world commerce, as well as safe and convenient passage for the largest existing ships, and for those larger ones which might "reasonably be anticipated." What does this present and coming commerce include? This must be set-

tled rightly at the outset. The canal is being built in the interest of a universal navigation. What will that navigation become, and what will it demand?

Mighty Impulse of Expansion.—The first fact that impresses one in this early year of a new century is that throughout Europe and America there has come a fresh, mighty impulse of expansion. Colonization, largely latent in the earlier decades, has taken a new force. From South Africa to the Philippines all the waste places are being occupied, and all available territory is being struggled for and appropriated. The invention of modern machinery in the hands of steadily growing capital has increased in the west myriad-fold the capacities for production, and the latest great movement is the fruit of it—the effort to enlarge the market. The American continent has during the years opened to an enormously greater consumption of European products. The European continent has reciprocally expanded to America's exports. The growth goes on compounding. In addition, both have now suddenly united in a resolute, impetuous advance upon the east—the sealed treasure house which they have set themselves to industrially and commercially conquer. We stand in an epoch age. We are witnessing the beginning of a movement laden with an influence greater far than the Crusades, whose vastness outsweeps the reach of an Alexander, whose dominion dwarfs the vision of a Napoleon. The nations of the west, standing in the portal of the twentieth century, have entered on the battle of the gods, and the stake is a peopled continent. What the struggle means, what Titanic effort and competition will ensue, what the ultimate rewards will become—these are almost beyond prophecy. In one statement alone we can dimly foreshadow them. Of all countries, America to-day stands first in its internal commerce. But its internal growth is of a few decades only; it has scarcely begun its career. Yet, already through the Sault Ste. Marie Canal, between Lakes Huron and Superior, there pass annually nearly three times as many millions of tons as pass through the Suez Canal. The American freight is supplied by but a few million people seeking this one of many available routes. To the east are eight hundred millions of people. What industries, what consumption, what exchange, what commerce, even in full recognition of the Orient's limited want,

lie as latent potentialities in that statement—eight hundred millions of people! Our speech can find no words to convey it. There exist the vast eastland populations, and here lies our destiny highway, Panama; America and Europe, eager, adventurous, are the young Jason nations, sailing out on the golden quest. What is their equipment, what is their strength, who will reach the goal, who will possess the fleece?

Must Anticipate Future Needs.—The nation that would conquer a great future must anticipate the needs and demands of that future and be ready for them. To be equal to immediate pressures alone is relatively to retrograde; it is to gamble on seizing and securing fortune by sudden heroic measures of relief. The countries whose interior waterways, rail routes, terminals and harbors are not ready to accommodate increase, cannot draw increase, for here also must the law prevail—to him that hath shall be given. Expansion is on the increase; it is gaining volume and momentum; it cannot be gathered back. This expansion is not alone internal in individual separate countries; it is particularly international and inter-continental, therefore it is supremely a movement oversea, a movement of navigation.

In this navigation contest the one best equipped will be he who can most nearly annihilate space and time. That the latest Cunarders are over 788 ft. long; that Leviathans of even greater capacity are already heralded by the latest cables; that multiplying fleets arise to nations bursting suddenly to power like the fleets flying the blazing-sun flag of awakened Japan—in such things one sees how well peoples are coming to know that the race shall be fierce and that its victory shall be to the swift and to the strong. Vessels must grow in speed, in size, in economy per ton-mile. When the limit is reached with available knowledge, then must ingenuity summon other forces, and the new supplant the old. Already the invention of a Parsons is working a revolution in the propelling mechanism of passenger ships; and the development of the gas engine promises by its adaptation, to nearly double the available equivalent of a pound of coal. In the tension of competition ships must be ever perfecting. They must be more and more skillfully handled; they must be massed in larger and larger numbers. Land transport and water transport must become more identical in interests. The era of the tramp ship is passing. To-day

the question is not of a ship, but of a fleet, and in the economy of transportation the very first demand is that not a moment of unremunerative time shall count against them; that facilities of ports, terminals, accommodations, shall be such that these flying shuttles shall never unprofitably pause.

Fight for National Supremacy.—The upbuilding and equilibrium of states, commercial stability and naval peace are all involved in these navigation principles. So thoroughly is now understood the meaning of the dominion of the sea, that all the progressive nations are in the throes of determined endeavor to wrest what they may of her dominance.

The question of naval power is one too vast to be even touched upon. The future of the armor-clad seems less predicable than that of the merchant ship. Its fate lies more in the hands of the inventor. A new gun, with a shell velocity of 4,000 to 5,000 ft. per second, will relegate navies as now built to the cairns of the Vikings.

There are thousands of lines along which the world has grown old enough to advance with premeditation, not at haphazard. One is surely this of preparing for the expansion of commerce. In considering the ship one must study the channel she is to traverse, and the harbors from which she goes and to which she voyages.

It was in contemplation of some such large general facts as the foregoing that Congress in the Spooner act set its definite goal. After 400 years of aspiration and endeavor for an Isthmian canal, the nation purposed building it once and for all. When at last America actually undertook to create this waterway and to leave it as a precious legacy to posterity she wished the waterway to be a fitting heritage. The act therefore was very precise that the canal must amply serve the needs of a world commerce and must afford a safe and convenient passage for the largest existing ships, as well as for those larger ones which might reasonably be anticipated.

The Suez Canal at its completion was supposed to have anticipated the need of centuries. Its sanguine eulogists ranked it among the enduring finished products of that land of monuments. Yet, after a lapse of only 30 years, its dimensions have proved so inadequate that the largest ships have quite ceased to essay it and are reaching Australia by the old weary route around the Cape. And this although the Suez has been in continuous process of deepening. So little

did these builders of 50 and even 25 years ago anticipate what the short interval has actually necessitated of enlargements at both Suez and Panama, that they deposited the spoil right along the canal banks. To-day, to secure larger dimensions, the old material must much of it be dug anew in addition to the excavation of the further channel.

The Manchester Canal, opened only ten years ago, is already being enlarged as is also the Amsterdam; the Kiel is about to be enlarged; the Soo is adding locks and even a state canal like the Erie was voted $101,000,000 to get dimensions into adequacy for the increase in sizes.

The United States has undertaken to construct an Isthmian canal. It has provided by formal enactment that this waterway shall serve the ships of war and peace in their future as well as their immediate development. It is therefore fundamental and necessary to resolve the question of the present size and draft of vessels and deduce what will be their increase in the immediate future.

The dimensions, which the impetus should demand in the locks at Panama are of much importance. To set at the termini of our waterway constraining locks is to put metes and bounds to the whole world's commercial growth. It is to limit civilization. What are the just and reasonable lengths that our waterway at the Isthmus should incorporate into its locks?

The average vessel engaged in ocean trade is the first type to be considered. As a generalization its class limit is now about 3,300 tons. This is the average net registered tonnage of the vessels using Suez, though it represents merely a theoretical point, since the tonnage average has been steadily advancing. Reduced to classification, this average is made up of ocean-going freighters, the swarm of tramps, the drudges of the ocean, whose usual length is from 200 to 400 ft.; of liners, whose average is less than 600 ft. long; of large liners, which now run nearly to 800 ft. The importance which this latter class has attained is the predominant note of modern vessel building. The 661-ft. Deutchland in 1900 was the marvel of its time. To-day there are under construction vessels 127 ft. longer. The Kaiser Wilhelm der Zweite, launched two years later, was 684.3 ft. in length. The Baltic, 708 ft. 3 ins., followed in 1903. With the assurance of the United States Government that a 40-ft. clear channel would be afforded into New York, the Cunard line has launched two vessels 788 ft. long of 88 ft. beam.

The whole tendency of merchant shipping is so manifestly toward greater size in all features that to lay a finger on a present ship is of small service in establishing the dimensions of a canal to serve the needs of even the immediate future. Nevertheless, the following list of vessels is given to crystallize into definite figures the modern large vessel dimensions in the merchant service.

Dimensions of Merchant Vessels.

	Year.	Length. Ft	Breadth. Ft.	Depth. Ft.	Draft. Ft.	Tonnage.
Gallia	1879	430	44.5	34.33	23	4.891
Servia	1881	515	52.08	37	24	7,392
Aurania	1883	470	57.17	37.17	25	7,526
Umbria	1884	501.5	57.17	38.17	25	8,120
New York	1888	517	63.5	42	27	10,798
Majestic	1889	566	57.67	42.83	27	10,147
Campania	1893	601	65.17	41.83	28	12,950
St. Louis	1895	536	63	42	27	11,629
Kaiser Wilhelm der Grosse	1897	627	66	39	28	14,349
Deutschland	1900	661	67.25	40.25	34	16,502
Celtic	1901	681	75.25	44.08	36	20,904
Cedric	1902	681	75.25	44.08	36	21,035
Kaiser Wilhelm II	1902	684.25	72.25	40.17	34	19,361
Minnesota	1903	608	73.5	41.42	33	21,000
Baltic	1903	708.25	75.42	49	36	23,876
New Cunarders	1905	788	88	60	36	.....

But we are not alone concerned with that ever advancing period, the present. What will be the vessels of the coming time? One way of attaining some idea is to find the rate of advance over a fair interval and apply it conservatively to the future. By the preceding table of longest typical ships of the year the growth from 1879 has been from 430 ft. to 788 ft., or at the rate of 13.8 ft. per annum. In fifteen years, at this rate of advance, we would see the 1,000-ft. ship. Another way of deducing is to calculate the influence of the margin of profit. Professor J. H. Biles made, a few years ago, such an investigation in a paper read before the British Institution of Naval Architects. His estimates of carrying costs as related to dimensions were made on the basis of vessel lengths of 500 to 700 ft. and draught from 27 ft. 6 ins. to 38 ft. 6 ins. Comparing the cost of carrying a ton of cargo 5,000 miles at 12 knots, he arrived at the following unit figures:

Length of ships—feet	500	550	600	650	700
First series; draft, 27 ft. 6 ins. over all. Cost per cargo ton	$2.19	$2.20	$2.34	$2.54	$2.73
Second series; draft varying; draft in ft. and ins.	27-6	30-3	33-0	35-9	38-6
Cost per cargo ton	$2.10	$1.95	$1.85	$1.76	$1.71

End of Ship Growth Far Distant.—It seems from this

table that while length in itself is not a source of cheaper unit transportation costs, increase in other dimensions, notably draft, as corollary to it does reduce them. The same facts were noted by our own Deep Waterways Board of 1900 for the Great Lakes trade. It is an unavoidable conclusion that the end of ship growth is far distant. We may expect to see even within a decade steamers 1,000 ft. long and 100 ft. beam, drawing over 38 ft. of water, and it is for these vessels, by which the business of America and of the world in the Pacific can best be done, that the American Canal must provide.

The critical dimension of a battleship is the beam. This is increased to counter-balance the lesser length, but below that of merchant vessels for convenience in maneuvering.

War vessels present a different aspect of the same tendencies. But there may accurately be said to be no present type or size. The accompanying table brings the development up to the year 1906.

Battleships.

Name.	Date of completion.	Displacement.	Length. Ft.	Beam. Ft.	Draft. Ft.
Warrior	1861	9,210	380.17	58.33	26.75
Black Prince	1862	9,210	380.17	58.33	26.83
Achilles	1864	9,820	380	58.28	27.25
Valiant	1865	6.710	280.17	56.33	26.67
Bellerophon	1866	7.550	300	56.18	26.58
Minotaur	1867	10,690	400	59.48	27.25
Northumberland	1868	10.780	400.33	59.47	27.06
Monarch	1869	8.320	330	57.5	26.58
Invincible	1870	6,010	280	54	23.17
Sultan	1871	9,290	225	59.5	27.5
Swiftsure	1872	6.910	280	55	26
Devastation	1873	9,330	285	62.25	27.5
Rupert	1874	5,440	250	53	23.58
Dreadnaught	1875	10.820	320	63.83	26.75
Alexandra	1877	9,490	325	63.67	26.5
Neptune	1878	9,310	300	63	26.08
Superb	1880	9,170	332.25	59	26.42
Inflexible	1881	11,880	320	75	26.33
Conqueror	1882	6,200	270	58	24
Agamemnon	1883	8,660	280	66	24
Collinwood	1886	9,500	325	68	26.83
Benbow	1888	10,600	330	68.5	28.33
Anson	1889	10,600	330	68.5	27.25
Nile	1890	11,940	345	73	27.5
Royal Sovereign	1892	14,150	380	75	27.5
Barfleur	1894	10,500	360	70	25.5
Majestic	1895	14,900	390	75	27.5
Ocean	1900	12,950	390	74	25.5
Formidable	1901	15,000	400	75	26.75
Duncan	1903	14,000	405	75.5	26.5
London	1904	15,000	400	75	26.75
Queen	1904	15.000	400	75	26.75
King Edward	1905	16,350	425	78	26.75
Lord Nelson	1906	16,500	...	..	.....

British Cruisers.
From Lord Brassey's Manual.

Name.	Date of completion.	Displacement.	Length. Ft.	Beam. Ft.	Draft. Ft.
Juno	1867	2,240	200	40.33	18.5
Inconstant	1868	5,780	337.33	50.25	25.5
Active	1869	3,080	270	42	21.33
Tenedos	1870	1,760	212	36	16.83
Thetis	1871	1,860	220	36	17.5
Shah	1873	6,250	334	52	26.46
Rover	1874	3,460	280	43.5	23
Boadicea	1875	4,140	280	45	23.67
Bacchante	1876	4,130	280	45.5	23.75
Euralyus	1877	4,140	280	45	23.25
Mercury	1878	3,730	300	46	22
Constance	1880	2,380	225	44.5	19.17
Arethusa	1882	4,300	300	46	20.5
Calliope	1884	2,770	235	44.5	19.92
Mersey	1885	4,050	300	46	20
Forth	1886	4,050	300	46	20
Magicienne	1888	2,950	265	42	17.5
Blake	1889	9,000	375	65	25.75
Edgar	1890	7,350	360	60	23.75
Cambrian	1893	4,360	320	49.5	19
Eclipse	1894	5,600	350	53	20.25
Powerful	1895	14,200	500	71	29
Arrogant	1896	5,750	320	57.5	21
Diadem	1897	11,000	435	69	26
Cressy	1899	12,000	440	69.5	26.25
Kent	1900	9,800	440	66	24.5
Drake	1901	14,100	500	71	26
Antrim	1903	10,700	450	68.5	25
Duke of Edinburgh	1904	13,500	480	73.5	27.5
Warrior	Building	13,500	480	73.5	27.5
Minotaur	Designed	14,600	...	..	.....

Not only is the general tendency toward enlarging war vessel dimensions to be reckoned with as a future determinant, but also the new principles lately developed. One lesson above all has been taught by the Russian-Japanese war—the imperative need of housing guns by pairs in turrets and doing away with large open spaces in which the bursting of a single shell may annihilate half the crew. This only recently appreciated principle has caused the redesigning of some new United States war vessels. It carries with it the necessity for even larger and wider battleships. Flotation must then be furnished for heavier armor and for the row of turrets disposed along the sides and fore and aft. Growth is exemplified by the new United States battleships now under construction, the Vermont, the Connecticut, Kansas and Minnesota, for instance, displacing 16,000 tons, or at full load 17,650 tons, 450 ft. long and 79 ft. 10 ins. beam, and the armored cruisers Tennessee and Washington of 14,500 tons displacement, 502 ft. length, 72 ft. 10½ ins. breadth, 27 ft. maximum draft. We are within sight of a battleship of 100 ft. beam and over 20,000 tons displacement.

The Standard.—It is for the vessels of this size and those to follow that the canal must be planned. The newest and the best must be able to pass safely through the American waterway. The great liners that connect Europe with America must be the standard of length and battleships the standard of width, not ocean tramps; the largest and most powerful vessels, not those already made obsolete by the lessons of the battle in the Sea of Japan.

The International Board collected statistics of vessel growths. They note of the Cunard steamers that those laid down in 1904 were 23% greater length and of 21½% more beam than those in use the year before, "and there seems to be no recognizable tendency to discontinue this expansion of dimensions of deep-sea vessels." "Already the Cunard Company has under construction two steamers 800 ft. in length and 85 ft. in beam." They decided in summarizing their studies, "that the convenient passage there will within a quarter of a century be used by ships 900 ft. long and 90 ft. beam seems not at all improbable." (Page 37.)

They adopted a quarter of a century as the interval which the canal should serve without needing enlargements to meet the legislative stipulation regarding "those which might reasonably be anticipated."

In conclusion, therefore, the following was decided: "As a basis of all plans the Board resolved by eleven affirmative and two negative votes that locks should have as minimum usable dimensions a length of 1,000 ft., a width of 100 ft., and a depth of 40 ft. The two members voting in the negative were Messrs. Noble and Ripley."

Later in the month of their travail, the Minority of the International Board having become possessed of a desire for their old 85 ft. level, were brought to considering ways and means for compassing it. The Bohio site for a dam was perforce abandoned. The compulsions of lockage water drove the dam down stream and it was put at Gatun. Mindi being a quite new competitor they did not familiarize themselves with its factors and conditions and they were moved to setting their locks all together in a flight in Gatun Hill. Here was a Procrustes bed indeed. The 1,000 ft. locks to which all but two had subscribed were cut down to 900 ft. lengths since the three were to be accommodated together. Even this abbreviated length took no reference to site needs for their Micawber summit-saving devices.

Narrowing the Value of the Canal.—It mattered not that each inch of shortening narrowed the value of the canal to posterity; it mattered not that the flight arrangement imperilled every vessel and battleship that would ever essay the canal—the 85-ft. level was held and the 900-ft. lock was installed as the measure of the world's carriers.

In an earlier paper the little "draughtsman's error" was considered and the valuable facts which, in the Senate testimony, it educed. These were, it will be recalled, that the locks of the experts, though nominally 900 ft. in length, were in real usable length 790 and 820 ft. long.

Mr. Parsons: "If the double gates are used, then the lock has an effective length of something less than 800 ft."

Mr. Stearns: "As nearly as I know, it would be 820 ft."

Colonel Ernst: "Eight hundred and twenty feet."

LOCK LENGTHS.

It shall surely require no detailed argument to convince men of any breadth of outlook that locks of such usable lengths on the Panama Canal are very deplorable. Nothing shorter than 1,000 ft. can be incorporated with any instinct of the value of this national waterway; of its place in commercial power; of its relation to dominion; of its alliance to America's destinies. The lock is the measure of the ships, commercial and naval, which the canal can serve. The thousand-foot lock alone should be considered for Panama. The adequacy of the Gatun Hill for three 1,000-ft. locks in flight, with safety devices to protect the summit level, shall be later considered.

Lock Widths.—From the profile and drawing of the flight series, one sees immediately that the Gatun locks are now planned by executive special order to be 1,000 ft. in the clear with the safety gates closed, instead of 820 ft., as the experts, the Commission and the Secretary of War all advised and so speciously justified before the Senate committee. Here again, as so often before, the experts' experting and the Commission's commissioning have been quite abandoned.

Another question arises: Are the proportions now wise and correct? Is a width of 100 ft. established by that order the proper dimension for a lock chamber 1,000 ft long in the clear?

The gauge of lock proportions is not the bulky, slow-steaming ore carrier of the lakes; the measure is not that

of the old liners, with simple twin screws, not even the more modern liners; it is the express steamers which exemplify the latest trends of progress in navigation and building. These are the guides, the standards which must forecast the future.

With the advent of the Parsons turbine and the multiple propeller system, which is its necessary feature, there has come silently to great liners a revolution in the relations between length and breadth. This is emphatically exemplified in the proportions of such late constructions as the Kaiser Wilhelm II. and the Mauritania, the new Cunarder.

Lock Width Limits Naval Growth.—The Kaiser Wilhelm II. is one of the best examples of proportions, largely due to the reciprocating engines and twin screws. The Mauritania is a late example with four screws. Four screws require beam for their proper mountings in the hull.

	Length.	Beam.	Proportion.
Kaiser Wilhelm II	684 ft. 3 in.	72 ft. 3 in.	1 to 9.48
Mauritania	788 ft.	88 ft.	1 to 8.99

These latter proportions will give a beam for longer ships as follows:

	Length.	Beam.
Ship, reciprocating engines	900 ft.	95.0 ft.
Ship, reciprocating engines	1,000 ft.	105.6 ft.
Ship, turbine engines	900 ft.	100.0 ft.
Ship, turbine engines	1,000 ft.	111.0 ft.

So much for the evolution of Express Steamers. In the Battleship there is another condition begotten of the need for quickness in turning. Beam is greater relatively to length. For example:

	Length.	Beam.	Ratio.
U. S. battleship Kansas	450 ft.	76 ft. 10 in.	1:5.85
British battleship Lord Nelson	425 ft.	78 ft.	1:5.45

If these proportions are taken as gauges, a battleship of even 545 to 585 ft. in length might be 100 ft. wide. Assuredly in the Dreadnought and the latest Japanese sea monster we are in sight of such creations.

The latest legislative anticipations are given thus:

"Owing to the foresight and energy of its Admiralty and the Parliament, no other country may expect to approach Great Britain in the competition. By 1910 the British Navy will probably own seven Dreadnoughts in addition to the three new battle cruisers of the Invincible class, which constitute the naval surprise of the season. A year later France hopes to have two great ships, the Danton and the Mirabeau, and Germany, in addition to a "monster cruiser" is planning for completion in 1911 four of the latest designs now projected."

To establish, therefore, a lock width of only 100 ft. is to limit naval growth unduly and to handicap the naval arm of our national defense. Besides, there must be a margin for fenders when the transit of such leviathans is considered; they cannot be suffered to grind along undefended walls.

All these considerations and their allied questions lead to the following conclusions:

U. S. BATTLESHIP "KENTUCKY" PASSING BATES DREDGER "HERCULES" IN SUEZ CANAL.

1.—That in a lock 1,000 x 100 ft. it is certain that the length is disproportioned to the width, and that, as express vessels shall evolve, craft no longer than 900 ft. could be later accommodated in it.

2.—That 100 ft. unduly limits also the size or beam of great battleship types which must be the dependence of the future.

3.—That no less than 105, and preferably 115 ft., should be the width of a Panama lock to suit the proportions of the large merchant and naval vessels of the near future.

The foregoing was written in January, 1907. In November, 1907, it is rumored that a new order is to be issued fixing the width at 110 feet.

OIL BURNING DREDGE "ONTARIO." NEW YORK BARGE CANAL.

CHAPTER XVI.

The Gatun Locks.

The Locks.—It becomes necessary to quote the following three letters before proceeding to analyze the situation they are supposed to unfold:

United States Senate, Committee on Interoceanic Canals, Washington, D. C., Jan. 8, 1907.—Dear Sir: At a meeting of the committee held this morning it was reported by one of the members that the borings for the locks at Gatun and on the Pacific side of the Culebra cut had been found unsatisfactory and that the proposed lock on the Pacific side had been changed some two or three miles from the original point designated. It has also been reported that the borings at Gatun were found to be very unsatisfactory, and it is the desire of the Committee that before Tuesday morning next (when our regular meeting will be held) you give us full information in regard to the borings that may have been had during the past year. It is the wish of the Committee that this be as full and complete as possible, as the rumor seems to indicate that at Gatun especially, the conditions have been found very unfavorable.

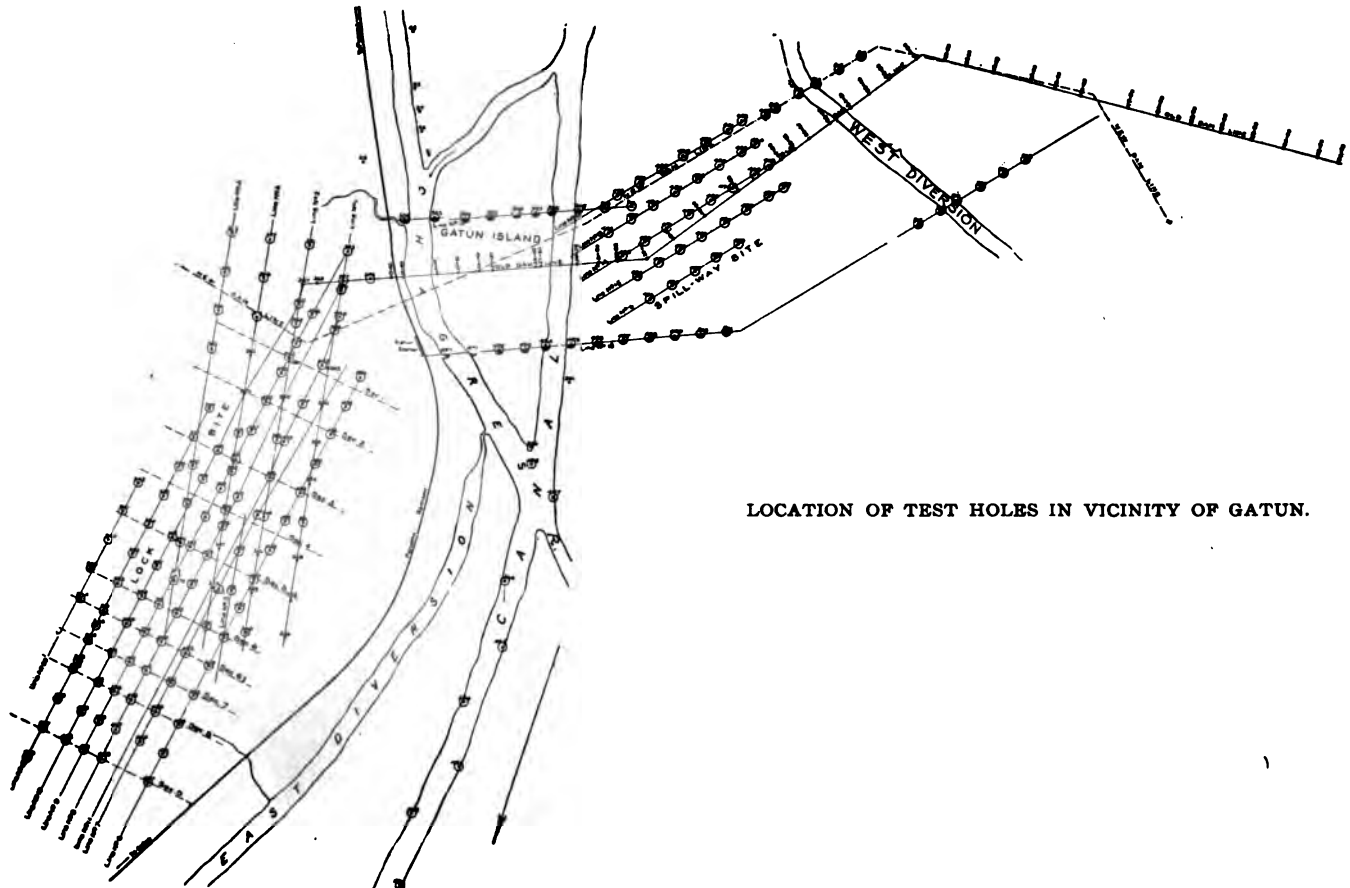
Respectfully yours,
J. H. Millard, Chairman.

Hon. Theodore P. Shonts, Chairman Isthmian Canal Commission, Washington, D. C.

Isthmian Canal Affairs, Office of Administration, Panama Canal Building, Washington, D. C., Jan. 14, 1907.—Sir: I have caused to be prepared by those members of the engineering committee of the Commission now in Washington (Messrs. Endicott, Hains and Harrod) a statement with respect to the inquiries set forth in your letter, and transmit the same to you herewith.

In order, however, that you might be advised of the results of all borings and investigations of a later date than those of which the engineering committee was advised, which include all those up to the time of its latest visit to the Isthmus in November last, a cable was sent to the Chief Engineer, Mr. Stevens, requesting that he advise me of the result of all borings to date, to which the following reply has been received:

"One hundred and twenty-seven holes have been bored at Gatun lock site, covering area 1,200 by 5,000 ft. All carried well below bottom lock walls, and 66 to the depth of 50 ft. or more below sea level, and all show that lock walls will rest on firm and suitable soft rock. Thirty-six borings made covering area of controlling gates for spillway. All show safe foundation in soft rock. Three lines of borings, 63 in number, all extending to rock, have been made across valley



LOCATION OF TEST HOLES IN VICINITY OF GATUN.

Chagres, covering dam site. Pervious material in only four holes, and these 200 ft. Pedro Miguel lock walls: Ten borings have been made below foundations, all showing rock suitable for foundations. Test pits Gatun and Pedro Miguel so far all show harder material than cores from borings."

While the report of the members of the engineering committee and the cable from Mr. Stevens relate primarily to the lock sites, your attention is called, nevertheless, to the statement that there is nothing in the later examinations made affecting the practicability or permanence of the Gatun dam.

Very respectfully,

T. P. Shonts, Chairman.

Hon. J. H. Millard, Chairman Committee on Interoceanic Canals, United States Senate.

P. S.—It is requested that, if practicable, the blue prints transmitted herewith be returned after they shall have served your purpose, as they are nearly all made from tracings on the Isthmus, and therefore would require considerable time to be replaced. T. P. S.

Isthmian Canal Commission, Washington, D. C., Jan. 2, 1907.—Dear Sir: In compliance with the request of Senator J. H. Millard, Chairman Senate Committee on Interoceanic Canals, of date January 8, 1907, referred to the Engineering Committee, it has the honor to transmit the following information concerning the borings at Gatun, accompanied by plan of all borings that have been made heretofore. This information is as full and complete as possible, including everything bearing on the subject of the Senator's letter, which is on file in this office.

No. 1.—Blue print showing locations of borings on lock site and dam site at Gatun.

No. 2.—Blue print showing borings additional to those on Sheet No. 1.

No. 3.—Blue print showing profiles of borings on or near the axis of the Gatun dam.

No. 4.—Blue print showing location of borings for the Gatun lock site, and the axis of the location adopted for the lock.

No. 5.—Series of six blue prints showing profiles on boring lines to develop lock site at Gatun.

Nos. 6 and 7.—Blue prints showing borings on cross sectional lines through the lock site and the relative position of the lock walls.

No. 8.—Blue print showing the stratification of material and the top of lock wall and level of lock floor on a profile along the axis of the locks, and also profiles on parallel lines 170 ft. east and west of the axis of the locks.

The Commission, at its meeting on November 20, 1906, directed the continuance of examinations to furnish information for the designing of locks, by sinking test pits under the lock walls, and the testing of block samples from these pits to determine the bearing power of the material and other physical characteristics.

The materials disclosed by the observations of the strata underlying the lock site show, below the surface soil, either what is denominated by the engineers in the field as "indurated clay" or "chopped sand and clay." These terms may be misleading. The chopped material is different from the indurated clay and seems to be a sort of hard pan or conglomerate, either of which will make a good foundation. Referring to the physical and not the geological character of these formations, the indurated clay has a rock-like consistency which resists compression and erosion, and makes an entirely satisfactory foundation for the proposed lock structures. This is established by borings and by the exposure of the material in the French work at the dry dock at Cristobal.

By the term "chopped," in connection with other material, is designated the method found most rapid and economical in penetrating it with boring tools. While a diamond drill was used in the so-called indurated clay, a chopping bit was found most useful in other material. It could have been taken out in cores by a diamond drill, and, in fact, this process was used at times. The terms are not intended to convey an impression of the value of their physical properties for a lock foundation. An opinion of the relative values of the two materials for foundation purposes is expressed in correspondence by Mr. Stevens, Chief Engineer, as follows:

"It will be noted that under the so-called indurated clay in cross sections 1, 2 and 3 exists what is called blue clay and sand—clay, gravel and fine sand, etc.

"This material, while not so hard as the so-called indurated clay, is in every respect an equally good and sufficient foundation, in my opinion, for the locks or a structure of any weight or importance. In fact, if there were not a particle of indurated clay in Gatun Hill I would not have the slightest hesitancy in founding the whole structure on this material.

"I beg in this connection to inclose under separate cover a sample of this material, which was taken as a core from the borings as it is found in cross section 1 as the material underlying the indurated clay, and I think you will agree with me that there is no doubt whatever as to its character for foundation purposes. I believe it is as good as indurated clay and good enough in any case."

We know of no foundation for the report "that the proposed lock on the Pacific side has been changed some 2 or 3 miles from the original point designated." The locks, both at Pedro Miguel and Sosa, occupy substantially the sites chosen by the Minority of the Advisory Board. These locations were necessarily general. When special examinations were made, it was found that the rock foundations for the locks at Pedro Miguel did not extend over the entire area covered by the structure, and a slight shifting of their position may be advisable, but there have been no other changes contemplated.

In conclusion, we state that the investigations which the Commission has continued have thus far led to no disclosure of extraordinary difficulties requiring changes of previous plans. The continuation of surveys has for its object the complete adaptation of the design of locks and other features of the plan to the existing surface and sub-surface conditions.

There is nothing in the later examinations made affecting the practicability or permanence of the Gatun dam.

Very respectfully,

Mordecai T. Endicott,
Chairman Engineering Commission.

T. P. Shonts, Chairman Isthmian Canal Commission.

It is to be noted that the Engineering Committee and the Chairman state that they gave to the Senate Committee the "result of all borings and investigations of a later date," in response to its demand for "full information in regard to the borings at this point (Gatun) and also any later borings that may have been had during the past year."

First, it is to be observed that the Chairman did not give the Senate Committee the results of the fifty borings which the Annual Report says were made during the year between Mindi and Gatun, and which had shown that some 1,637,000 cu. yds. more clay-rock were to be encountered than had been heretofore estimated between these points, as this series has already shown. Where are they? Why are they not available?

Second, it is to be observed that the results of the new borings on Spillway Hill are nowhere disclosed among the boring profiles. Of what service is it to be told where a bore is, with not a shred of data vouchsafed as to the field records of the strata and formations met? Were permeable sand and gravel found under the clay-rock of Spillway Hill, as under all the locksites?

Third, it is to be observed that no data whatever are given as to the new bores in the valley and gorges. Evidently these did not exist in Washington, January 14, 1907, since the Commission gave up its little all. On the cut herewith presented these important borings are distinctly marked.

It is hardly to be expected that the Senate Committee could make a technical study of the apparently formidable array of blue prints, but this shall be done.

The prints embrace a year's study. The exhibit should be now very exact and complete, if it ever is to be exact and complete. Surely nothing defective or undigested would again be

handed to this tribunal of legislation. The locks will be in the right spot—after a year upon "a peak at Darien" cogitating and planning for the ships that will pass in the night. The lock walls will be at the right elevation. An expert testified: "I made the plans of the lock myself, Senator; I made the estimates of them; I sketched out the plans of the lock personally, and I personally made the calculations of the quantities." Then there was a retreat behind the draftsman's error that compromised much wisdom. With a twelvemonth in which to exercise full care there will be no further errors in this chef d'oeuvre. As a commentator rejoices, "there will be nothing for the other gifted men to do when they stand together again on the scene of their inspiration but to agree with all that their fellow experts have evolved in their year of toil."

This series of blue prints does not embalm all that the "designers of locks" have done during the past year. There have been made some fearful and wonderful projects for safety devices to hold up one great lake—Gatun. Sosa Lake is still intrusted to Providence and no safety devices have been incorporated or estimated against its miles of imminent water. But some handsome, if not handy, devices have been prepared as safety dams to check the mad rush of Lake Gatun at 30 miles an hour if a vessel plunges headlong down its flight of locks. These appliances will be analyzed in due season.

Meanwhile, we examine the blue prints. They tell the story of where this country is to invest untold treasure and much hope.

No. 1.—Blue print showing locations of borings on lock site and dam site at Gatun.

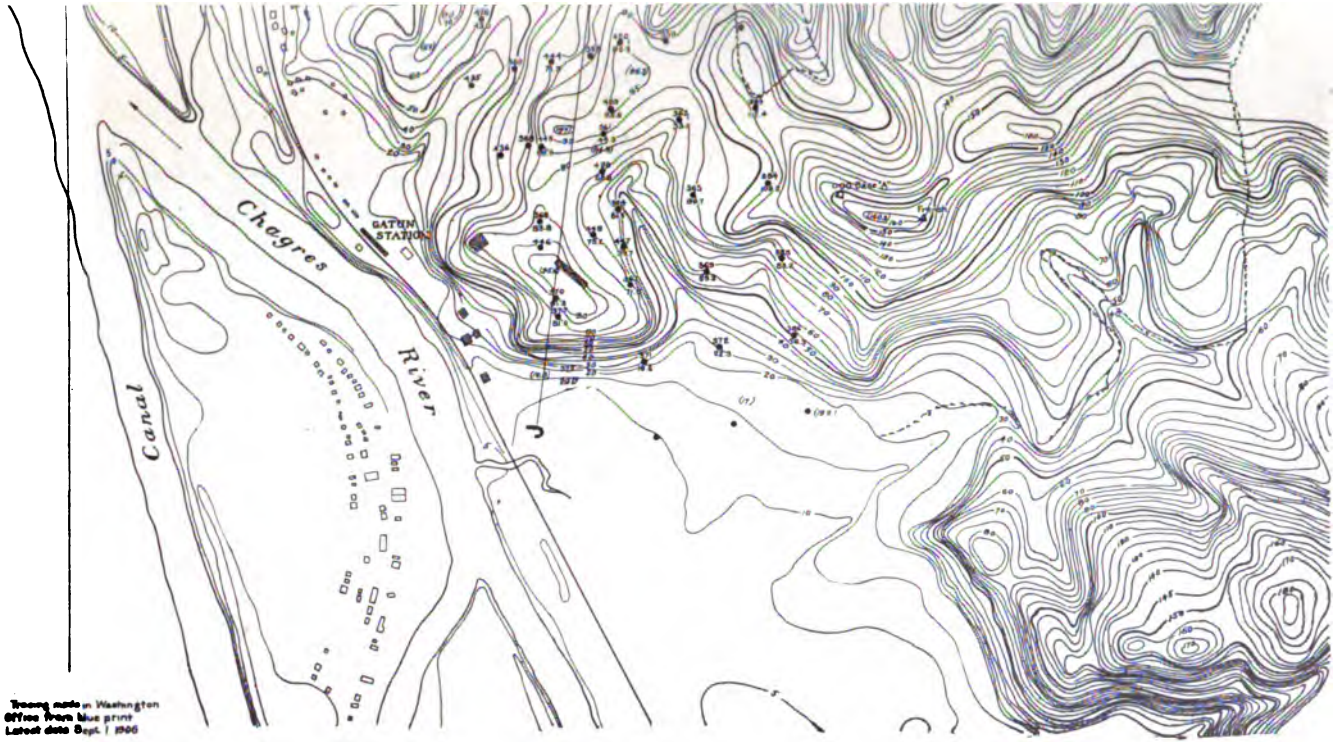
No. 2.—Blue print showing borings additional to those on Sheet No. 1.

These are not two prints, but one, and Locksite and Spillway Hill have truly been peppered at last with new bores.

No. 3.—This has a familiar face. It is the Maltby profile of November 3, 1905—our artesian friend of seven flowing holes.

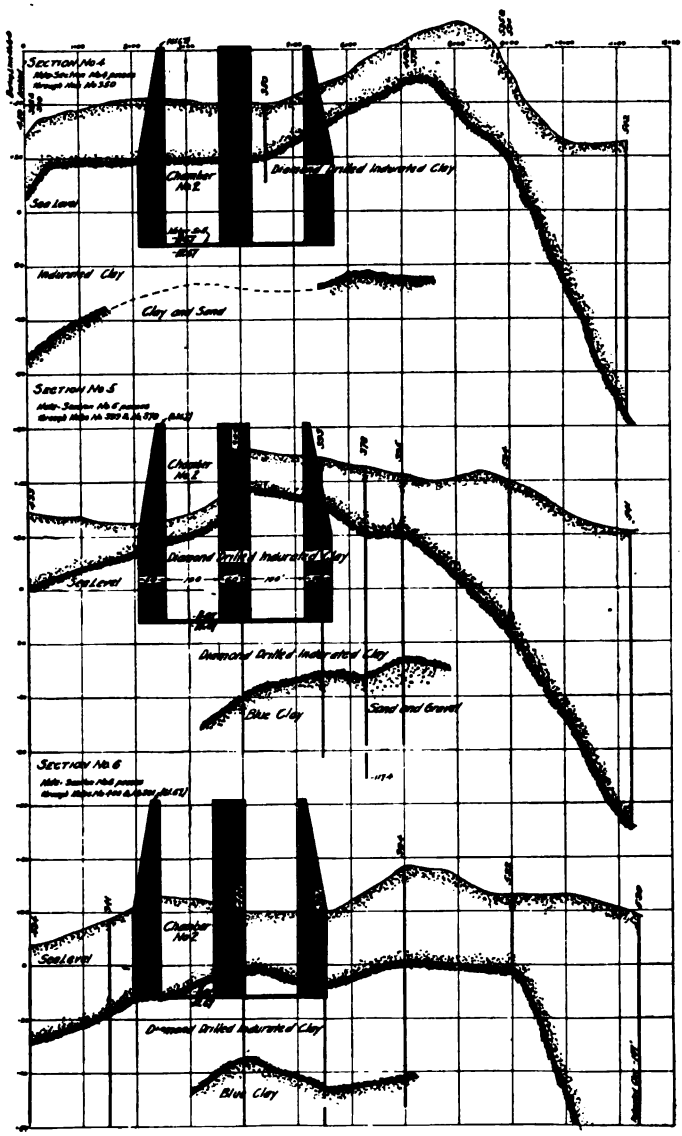
No. 4.—Is a detail of Nos. 1 and 2, only a contour map.

No. 5.—Shows the profiles of the locksite bores, whose results are embodied in Nos. 6 and 7 (one sheet)—sections of geologic strata and lock-wall sections. This is a very important and striking document when taken in connection with its longitudinal mate, No. 8.



LOCATION OF TEST BORE HOLES, GATUN LOCK SITE. OFFICIAL DRAWING NO. 4.

Note
The numbers above the bore holes indicate the number of the hole
The numbers beneath the bore holes represent elevations the datum
plan of the surface of the ground at the hole



SECTIONS, NOS. 4, 5 AND 6.

Such is the blue print tally; but it holds the lock story to him who knows how to read. It is necessary from the data afforded by Nos. 5, 6, 7 and 8 to make more vivid the picture which they unroll.

One of the accompanying cuts is a longitudinal profile, which shows the situation lengthwise under the center and the east and west walls, with the record of every bore and section duly transcribed. Page 198.

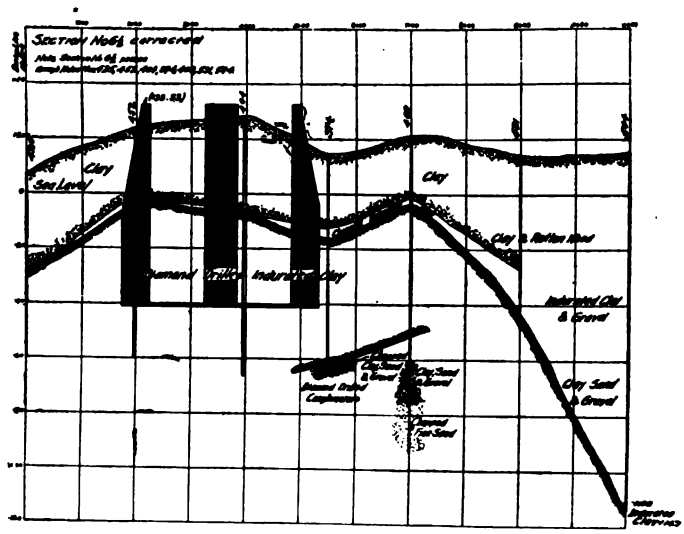
Before referring to it in detail, it is necessary to give attention to the various lock sections of drawings Nos. 6 and 7, and to drawing No. 4, whereon is shown "the axis of the location adopted for the lock."

Both drawings are here reproduced in order that the analysis can be followed.

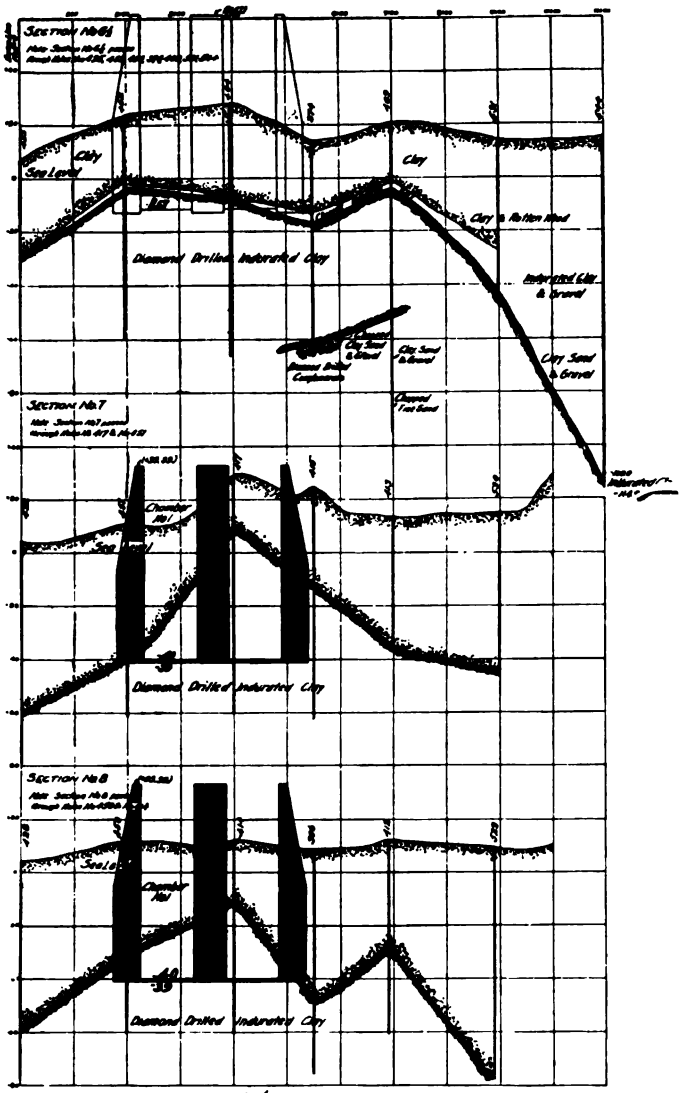
The language of the letter is precise. "The axis" of the location of the lock flight is "adopted." There is no question, therefore, as to the position and course of the axis. The only movement of the design must be either to the northward or the southward.

The map of the borings shows all the latest as well as the earlier borings—some 127 holes.

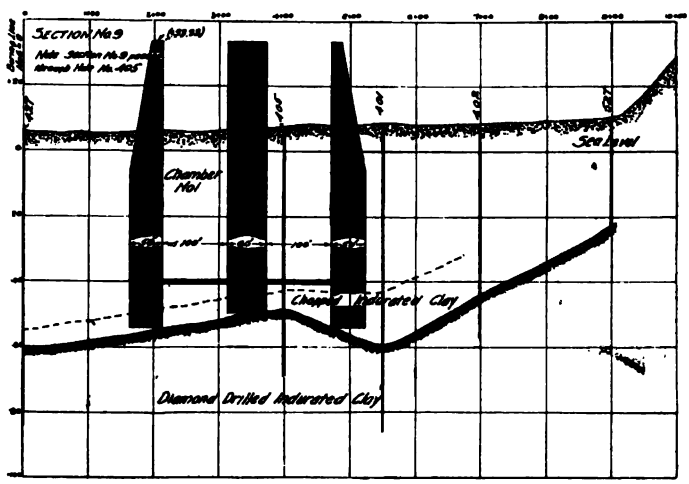
There are presented for the



SECTION, NO. 6½, AS CORRECTED.



SECTIONS, NOS. 6½, 7 AND 8.



SECTION, NO. 9.

Twin upper locks, sections 1, 2 and 3. For cut, see page 201.

Twin middle locks, sections 4, 5 and 6.

Twin lower locks, sections 7, 8 and 9.

In addition to the above, another cross section is interpolated marked Section 6½ in which the lock walls are drawn for the middle set of locks, but as a matter of fact the section is developed by Bores Nos. 425, 452, 404, 374, 409, 531 and 544, and the line joining these bores as shown by Drawings Nos. 4 and 8 passes through the lower twin locks, not the middle ones. The section is manifestly a tripping, an error as the lock walls are set 28 1-3 ft. too high. A corrected drawing is presented showing where the lock walls should have been located in a reliable and responsible study. The Senate Committee was not told how incomplete and inaccurate was the presentation it was receiving in response to its demand for data.

Cognizance is also taken of an error in Sections Nos. 7, 8 and 9—in the depth markings under the lock walls and bottom. The level—39 should be—41. These errors are significant because, occurring in drawings thus officially put forth, after (inferentially) extended reflections upon this, the most crucial feature of the waterway, they evince still such lack of care and exactness as under the circumstances is

extraordinary. The maps supposedly set forth the results of nearly a year's close study by the Commission, and they are disquieting for this reason.

The geologic formations at these sections purport to be demonstrated by the following tabulated data:

Section No. 1. Through upper guide walls. For cut, see page 201. The first noticeable thing is that the study is based upon a distance between lock walls of 100 ft. This gives a margin of but 6 ft. on either side of the new Cunarders. Second, the center wall is 60 ft. thick and the side walls 50 ft. each. The dimensions apply to all the locks. It also becomes possible to ascertain and consider another ruling dimension—the usable length of the locks between the safety gates.

It will be recalled that the Minority and Commission experts presented a year ago a report claiming that they had provided for locks of 900 ft. minimum usable length and that it was then developed from the Senate Investigation that their locks with the safety gates in position were really 820 ft. or less in the clear. No official announcement of any change has been promulgated. No reference to this vital question appears in the Isthmian Report of 1906 or in that of the Chief Engineer.

The 1,000-Ft. Lock Resurrected.—The Panama Canal in its every feature and detail lies fundamentally with the technician; even further, with the very specialized technician. But here, conversely, is the paradox true, that the man who is alone a specialized technician is perhaps the one least fitted for measuring adequately his own problems. A man must be large enough, universal enough, to be master of his subject, not solely in its narrow limit, but in its very broadest, in its every connection and relation, if he is really fitted to know and to solve. The electrician who understands electricity alone is not equipped and cannot make a large electrician. The engineer who is not able to measure the relation of his science to a world's needs is a limited engineer.

Those abbreviated lengths were severely criticized by even the most partisan technical journals supporting the Government's general type, and the hope was expressed that the Executive would yet rescue the locks from the compressive clasp of his engineers. But the months went by and the too short lock, like all the rest, was obstinately defended. At last, without a word, into an official blue print is slipped the 1,000-ft. lock.

Varro losing Cannae and leaving an open way for Hannibal to the Gates of Rome, was thanked by the Senate "because he had not despaired of the Republic." Our Executive might honorably be thanked also because though accepting a Cannae once for the World's Commerce in an 820-ft. lock, he, and he alone of the Panama management, did not despair of the Republic. He still had some faith in his country's future. Despite the sophistry and the pleas for official consistency he has risen and rescued the Canal from the fetters that were forged for it. He has ordered the 1,000-ft. lock.

Bores Tell Nature's Secrets.—The lock foundations are next examined.

Borings at Sections.

Borings on or Close to Line Number.	Borings Applied Number.	Remarks: Bore Numbers.
Upper Locks—		
Section 1 ... 1	2	**443, 436, 362.**
Section 2 ... 1	1	**420, 359.**
Section 3 ... 4	1	**424, 352, 421, 418, 537.**
Middle Locks—		
Section 4 ... 8	1	**429, 382, 349, 350, 419, 379, 535, 536, 542.**
Section 5 ... 7	.	**433, 399, 393, 378, 395, 534, 541.**
Section 6 ... 7	.	**434, 341, 400, 391, 394, 532, 539.**
Lower Locks—		
Section 6½ .. 7	.	**425, 452, 404, 374, 409, 531, 544.**
Section 7 ... 6	.	**432, 451, 417, 415, 413, 430.**
Section 8 ... 6	.	**428, 450, 414, 396, 412, 529.**
Section 9 ... 5	.	**427, 405, 401, 402, 527.**
Total..... 52	5	

NOTE.—The line of the sections passes through the bores whose numbers are in black type, the others are more or less off the line.

Section No. 1 is taken at the uppermost gate chamber. One notes that it is presented on the data of but three holes, two of which are not in line with the section. "Applied" hole 436 is over 240 ft. distant from the left wall.

Bore 443 is 555 ft. from 436 above. Some 240 ft. further distant is "Applied" hole 362.

In these data one examines the lens-like exhibit of "Diamond drilled indurated clay," whose depth and extent have been deduced in part from the longitudinal section under the left wall. This oblate sheet of clay-rock is shown bounded on the sides and bottom by "sand and gravel," "yellow clay," "sand and gravel" and "blue clay," besides the superficial clayey blanket which characteristically covers the clay-rock. Hole 443, after passing through 20 ft. of rock, went through 70 ft. of sand, gravel and clay, and then struck another sheet

of clay-rock about 12 ft. thick 38 ft. below sea level. According to the section showing the right guide wall, a concrete mass 50 ft. wide by 54 ft. high tapering to 15 ft. at the top, overhangs the rock lens and is founded in part on "sand and gravel." Since, presumably the best axis for the lock-ladder has been determined, and this axis is in the chairman's letter to the Senate announced as adopted (Drawing No. 4), it is manifest that the only change of position must be brought about by moving the flight bodily—south or northward.

The profiles, No. 8 and the one here presented, indicate that the clay-rock sheet thins out south of section No. 1, and that any southward movement of position brings these crucial lock-gate chambers off the rock and on to the strata marked "sand and gravel" and "clay," which are practically certain to be saturated by the waters of the lake which rise above them.

Special measures will therefore be incumbent to confine the "sand and gravel" laterally and to minimize the uncertainties of "blue and yellow clays," which in so many ports have proved their title to respect and the need of watchful care. The boring data southward from Section No. 1 are deplorably deficient and insufficient to determine the sequence of the strata of "clay rock," "sand and gravel," etc., whose presence has been shown in the few borings here reported.

Likewise it is impossible to know from borings so far apart as to the soundness of the rock encountered. It is certain that the surface clays, or those next to the rock, are the products of decomposition and weathering, and where the sheets of indurated clay are thin it may well be that it is not sufficiently sound for foundation purposes.

Rock Blanket Rests on Sand.—It is amply demonstrated by the profile deduced from the sheet of sections Nos. 6-7 and profile No. 8 that underneath all the locks the indurated clay-rock lies like a blanket over a mixed formation of "sand and gravel" and various colored clays. This hard blanket varies from 18 ft. thick at section No. 1 to 66 ft. thick at section No. 5, in the middle lock, but under the lower lock and approach its thickness is unknown. There are no data to reveal it.

Of the uppermost lock works, the south 600 ft. are founded on "sand and gravel," "sand and clay" and "blue clay," which underlie the rock blanket which must be cut

away to reach the required depths for the masonry under the gate chamber and upper guide walls.

Similarly one sees that the rock blanket is nearly pierced at the lock-gate chamber between the upper and the middle lock, and that it is quite cut through under the gate chambers between the middle and the lower set of locks resting on a stratum of blue clay under the center and walls.

Further, the bottom of the lowest gate chamber has to be upbuilt about 15 ft. from the rock, which at section No. 9 is disclosed as being from 50 to 60 ft. below sea level, or from 56 to 66 ft. below the surface of the "Swamp of the Quicksands." The north end of the lower lock, for from 300 to 350 ft., has to be also upbuilt from the rock. In both of the approach walls on the north to the lower set of locks, the full length is in the swamp.

No data are presented as to the whereabouts of the rock-blanket in the whole extent of the approach walls, a stretch of a quarter of a mile. The dip would apparently carry the rock very deep.

This would mean excessively costly approach walls if an attempt be made to found these important adjuncts as they should be on rock. If they are to be founded on piles or cribwork, it is a serious business in this morass. Actually all the works of this approach and all of the lower lock itself, are in the swamp. In order to gain room for the lock flight, which should not go any farther south, the swamp has had to be invaded for nearly half a mile.

"Can build two sets of three locks, each 1,150 ft. long if necessary, and perhaps much longer. Conditions ideal for construction and permanency. Say that if nature had intended triple locks there she could not have arranged matters better."

The above was wired by the late Chief Engineer when the Commission was battling with the Senate committee for the 900-ft. lock, which they have all now so silently abandoned. Well, some people's ideals on sites are quaint in emergencies.

As one sees the profile of a year's study it is plainer than ever that only one lock can be safely imbedded in the sound rock above the underlying bodies or strata of "blue and yellow clays," "sand and clay," "sand and gravel" and "chopped indurated clays" and "chopped fine sand."

This latter novel and ingenious term in geologic litera-

ture is explained in the letter of the Engineering committee to the Senate January 14, 1907. It reminds one just a trifle of the "chewed" cabbage of the March hare or the "pawed gravel" of the prairie gopher.

Examining the sections Nos. 1 to 9 it is observed that this unique nomenclature is applied to only two sections—No. 6½, where one finds that it relates to a thin stratum some 2 or 3 ft. thick between the two clay-rock sheets; another where it appears to have been a conglomeration of "clay, sand and gravel." and one in a nearby bore, where it is "chopped" fine sand. On section No. 9 is found "chopped indurated clay" overlying the clay-rock. Likewise, the Chief Engineer refers to the so-called "blue clay and sand," "clay gravel and sand, etc.," under the indurated clay blanket shown in sections Nos. 1, 2 and 3.

In the Realm of the Unknown.—The Chief Engineer writes:

This material, blue clay and sand, clay gravel and fine sand, etc., is in every respect an equally good and sufficient foundation, in my opinion, for the locks or a structure of any weight or importance. In fact, if there were not a particle of indurated clay in Gatun Hill I would not have the slightest hesitancy in founding the whole structure on this material.

This statement of the Chief Engineer is indorsed and supported by the Engineering committee. Here is where the writer would join issue. If these strata of "blue clay and sand, clay, gravel and fine sand" could and would remain through coming time as they exist to-day compacted in a dry, solid mass, then the decision might be safe. But the interposition of an 85-ft. lake immediately upon completion of the locks brings at once 85 ft. of water with its hydrostatic pressure, to change radically the quality and the condition of this "blue clay and sand, clay gravel and fine sand." What will be its qualities, its sufficiency then? No one living knows or can know. Will the clays develop the "sliding" tendencies noted by the English constructor? Will the slow undercurrent carry out some of the finer sand, as Dana and Geikie so clearly illustrate, and will the voids impel more and more settlement? All this lies in the realm of the unknown, and in the realm of such serious consequences if all be not favorable, that conservative engineering will not unnecessarily hazard it. Such construction as can be rightly

founded in impervious clay rock alone should be permitted in these three momentous locks.

Further, the question is not alone one of the locks themselves, but one also and integrally of substantial and proper approaches at both ends of such a flight, and supremely of the incorporation of proper and safe safety devices for conserving the summit level in the event of disaster to the gates. These bodies or strata of clay and sand and gravel were the products of volcanic action and of the erosion of the hills of the secondary formations on the Isthmus. They were brought to the locality in which they are encountered by water, and certainly water once saturated and circulated through them. The lake must restore in part the ancient conditions, and any ill effects of saturation and even slow circulation under the locks and along the sides of the great concrete walls must be considered. The situation is not like that at the rock-ribbed Soo.

Not the Brown Rock of Mindi.—Before the writer are some samples of this "Diamond Drilled Indurated Clay" of the sections and the profile. They came from the bottom of the test pit sunk on the top of Locksite Hill at the southern end of the upper lock. In this material the late Chief Engineer reports progress in sinking of but "a foot a day" won every inch "by blasting." The sample is from the soundest part of the lens-like body shown in section No. 1. It is the "Diamond-drilled indurated clay"—the "whet-stone" of Mr. Stearns, the "soapstone" of Senator Knox, what we have called in this series "clay rock." What is it? "A rose by any other name would smell as sweet." The latest edict at Gatun for all employes is that they shall call it "soft rock." This sample is not the brown rock of the Mindi bore-cores nor that of the Mindi Reef or Cliff which in Jaramillo Hill overhangs the French canal; it is not that of the dry dock at Boca-Chica, it has a quite different color, bluish, that is brownish. To the taste the Gatun lock-site sample is clayey. It clings to the tongue like a madstone, being very absorbent of water, showing that between its fine grains there are voids where capillary attraction is strong. In small pieces it deliquesces in water and disintegrates rapidly in the moist weather and makes a paste. It is the very substance which impastes the volcanic shattered secondary rock formations of the backbone of the isthmus. Sometimes these shattered angular

particles are large—sometimes small. Many have seen the samples from Mt. Pelée which abound in our museums. Pound one up and mix the powdered substance with water, dry out the cake and the result will have the attributes and the appearance of this "soft rock," this "Diamond-drilled indurated clay." It is proven to lie in blanket-like formations under a surface clay. It covers thick and thin strata and bodies of sand and gravel, the latter evidently river-borne. There is a normal explanation which covers it and which is corroborated by much other evidence at the Isthmus. The substance was once semi-liquid, it must have been either sedimentary or volcanic. If it were strictly sedimentary, it would be in layers or have partings, as sand-stone has, but this is not the case.

The geologist Geikie writes:

Solidified Volcanic Mud.—"Volcanic tuff is the name given to aggregates of the finer-grained ejectmenta. These are often arranged in layers and beds which have been spread out by water action. There are endless varieties of structure and texture —some tuffs consisting of lapilli, or of grit, or of sand and ash; others made up of all three, and not infrequently arranged in lenticular layers and beds. Some volcanic tuffs consist of the finest ash-like material, forming a dull, fine-grained or compact rock which varies in color from white to gray, to darker or lighter shades of red, blue, yellow, etc."

Dana speaks of it thus:

"When the rains come down in torrents during such an eruption the projected materials make the flowing mud (called tufa when it is dried and hardened) that buries fields and forests and has made fossils of cities, of which Herculaneum and Pompeii are examples. Extensive tufa deposits are made by volcanoes of all kinds, but especially by those of the second and third kinds. Some accumulations apparently from a single series of discharges, without intermediate streams of lava, have a thickness of 1,000 feet or more and cover thousands of square miles. To the eastward of the Cascade summits, Oregon, Mr. Condon speaks of traveling over an area of tufa for 50 to 60 miles and states that the volcanic ash was evenly laid over the whole surface like a covering of snow, and where attaining its greatest thickness the sharp features of the older surface ceased to show themselves through it. In many parts of the Rocky Mountain regions the tufas contain silicified stumps and trunks of large trees."

Study leads one to the conclusion that this Gatun "soft rock," this "diamond-drilled indurated clay," this "clay-rock," is simply solidified, volcanic, clayey mud, once in a semi-liquid pasty condition and caked here just as at Pompeii and

at Herculaneum, at Pelée, and lately at Vesuvius. One understands why it overlies river-borne sands and gravels which are permeable. One understands how at Culebra is found this tough, caked volcanic mud and underneath it completely saturated strata of sand and gravel so porous that the boring tools get lost and the pressure water of the wash-boring devices suddenly falls when the drills break through the crust. This explains also why the Isthmus is the land of so many springs. Not all Panama hills are of this formation. The great cliff at the Rio Indio, on the Chagres below Gatun, is like the hard volcanic trap at Bas Obispo, where the crusher is working. Jaramillo Hill is not like Locksite Hill. They are different products of the varying geologic eras of Panama.

Let there be no illusions—this "diamond-drilled indurated clay," this Gatun "soft rock," is merely well-caked volcanic mud, and not the rock of the eternal or Laurentian Hills.

CRUSHER AT BAS OBISPO.

Subsoil Stability.—The foundations under the Gatun lock flight have been reviewed in the light of the borings sent recently to the Senate Committee. The environing conditions and the full meaning of the substrata can be perhaps best impressed in connection with certain laws of construction.

Paraphrasing the latest authority, Mr. Bryson Cunningham, in his great work, "Dock Engineering," we quote:

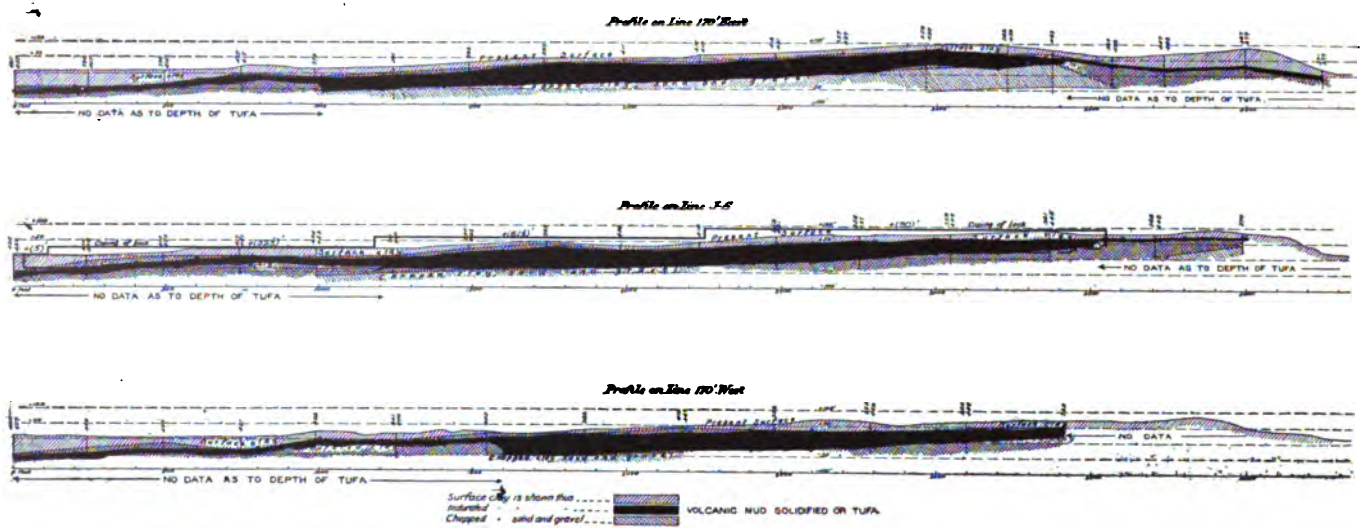
"Under ordinary conditions, such lock walls receive certain though varying support from the hydrostatic pressure on the face which more or less neutralizes the earth pressure from the rear, but the lock may have to be allowed to run dry or be pumped for repairs or alterations, and it is advisable to neglect the frontal force of the contained water and treat the wall as a retaining wall pure and simple. But even in so doing it must be admitted that the range of contingencies to which a dock (or lock wall) is liable far exceed those affecting an ordinary retaining wall.

"Hydrostatic pressure alone may more than double or halve the factor of safety in a given wall! Thus, with a well puddled lock bottom, the subsoil water in the ground at the back of the wall may stand far below the level of water in the lock, and the hydrostatic pressure may thus wholly neutralize the lateral thrust of the earth, or even reverse it. On the other hand, with a porous subsoil at a lock entrance, the back of the wall may be subjected, with an emptying lock, to the full hydrostatic pressure due to the lake plus the lateral pressure of filling." This is the situation at Gatun.

"Again, the water may stand at the same level on both sides of the wall, but may or may not get underneath it. If, however, as is perhaps more frequently the case, the wall is founded upon a porous stratum, the full hydrostatic pressure will act on the base of the wall and reduce its stability in practical cases by about one-half."

This again is the situation at Gatun. Quoting further:

Overturning Forces.—"The actual extent of the overturning wedge and its effective pressure can only be matters of conjecture. It is common experience that unsupported earthwork stands at widely different slopes, according to the nature and conditions of the particles of which it is composed. To a limited degree experiments have determined some of these slopes and fixed what is termed an angle of repose for the more prominent kinds of earth. But the values attached to these angles can only be regarded as of an approximate nature, as will be evident from a glance at the following table, comprising maximum and minimum results obtained by different experimentalists:


Profile on Line 170' East
NO DATA AS TO DEPTH OF TUFA
NO DATA AS TO DEPTH OF TUFA
Profile on Line 3-E
NO DATA AS TO DEPTH OF TUFA
NO DATA AS TO DEPTH OF TUFA
Profile on Line 170' West
NO DATA AS TO DEPTH OF TUFA
NO DATA
Surface clay is shown thus
Indurated
Chopped
sand and gravel
VOLCANIC MUD SOLIDIFIED OR TUFA

OFFICIAL PROFILE OF GATUN LOCKS, SHOWING NATURE OF MATERIALS AS DETERMINED BY BORINGS.

Material.	Range of Angle of Repose. From.	To.
Gravel and shingle	35°	48°
Dry sand	21°	37°
Vegetable earth	28°	55°
Compact earth	40°	50°
Well-drained clay	40°	45°
Peat	14°	45°

Ranges so extensive render it an exceedingly difficult matter to assign any angle to a variety of soil, however specific, especially in view of a further modification due to its degree of humidity. The amount of moisture present in the sample under consideration very materially influences the experimental result obtained for its angle of repose. A slight quantity, just sufficient to occupy the interstices between the grains of solid matter, has been found to increase the frictional resistance to movement and, accordingly, to produce a correspondingly greater angle of repose. Any excess of moisture, however, over and above this trifling amount results in a diminution of the frictional resistance; and if the humidity be indefinitely increased, the material eventually acquires a muddy consistency, to which there is no angle of repose worth noting. Ordinary clay, for instance, in the dry condition crumbles at 40 degrees; moderately moist, its inclination may be increased to as much as 50 degrees; allowed to become saturated, it subsides at an angle of 10 degrees."

"An Engineering Triumph!"—Such is the quality which will be begotten by the 85-ft. lake in the materials which underlie the volcanic tufa. In and on this tufa the lock chambers, of enormous weight, are partly founded; partly also they are founded directly on these permeable strata, and the approaches and safety dams are entirely on them.

It is this change of angle through saturation which is producing the large slide on the north slope of the hill at Culebra, the two small slides on its face and particularly the great reddish clay slide, ever moving, like a glacier, on the south side of the hill. It was such clays, saturating, which so continuously balked the French. Note the following:

"Argillaceous (or clayey) earths are most susceptible to the deteriorating influences of moisture, and any admixture of sand with the clay only produces an accentuation of the evil, because the impermeability of the clay offers an obstacle to the escape of water which has entered through the pores of the sand. A striking instance of this is afforded in a notable landslide behind the quay wall at Altona."

Lock Foundations.—At Gatun there is the lake at 85 and locks full and empty having an intimate relation in their walls to prospective saturation of the encompassing soils.

"The walls of locks differ from the ordinary type of dock walls in that they derive a considerable amount of support from the floor, especially if, as is usually the case, the latter has the form of an inverted arch or, if a flat floor, has curved haunches tangential to the side walls, or, failing that, is sufficiently thick to admit of the existence of a virtual arch within its limits."

The official studies sent to the Senate Committee in Sections 1 to 9 show astonishingly thin floors.

"As a general rule, hard rock and stiff clay, in which there are no springs, do not call per se for any artificial covering except such as may be judged necessary to protect their surfaces from the softening and scouring action of water. On the other hand, alluvial deposit, sand, gravel, and other non-cohesive strata, need the confinement afforded by a superimposed mass. Earth of a porous nature, moreover, is not only unsuitable for a natural floor, but is equally undesirable as a foundation for an artificial floor, owing to its efficacy as a medium for the transmission of water pressure, on which account any covering laid upon it should be both strong and impervious.

The point of perhaps the greatest importance in connection with lock foundations is that of treatment of boils and springs, such as are often encountered in works of this class. The type of foundations most likely to cause trouble in this respect is that in which a pervious stratum lies between two others of an impervious nature, the upper of which has been pierced or is fissured by a natural fault. The water-bearing strata may then discharge copiously under considerable head, owing to a connection with some external supply located, often unexpectedly, at some remote inland source."

This is exactly the situation which will obtain under aggravated hydrologic conditions with the lock-flight at Gatun, in both its construction and maintenance.

Prudence Thrown to the Winds.—One cannot, in view of them, contemplate with the equanimity of the Commissioners and Secretary the risks which indubitably attach to an 85-ft. head in a lake against the formation under the locks as projected in this Gatun Hill. The "studies" in Section 2 and 9 and the lock lengths adjacent show very thin bottoms, indeed, next to "clay and sand and gravel" strata there. Nothing reflects the prudence which the situation demands of a designer.

Upon an inspection of Profile No. 8 and that compiled from the Sections Nos. 1 to 9, certain facts are convincingly evident:

The north approach walls, about 1,250 ft. long, are in the "Swamp of the Quicksands." Where they join the lock

chamber it is nearly 60 ft. to rock below sea-level and some 66 ft. from the surface of the morass. No boring data, if such exist, have been presented, and the dip of the rock would seemingly carry it to depth precluding a rock-founded quay or dock approach.

Here, then, there must be a saturated-morass pressure against an approach wall some 50 ft. high. Surely these approaches must be stable structures. They constitute an engineering work of great cost and importance. It is not for the United States to build anything but permanent and substantial dock walls in the approach to so important a staircase of locks. The outrush of lockage water and the incident currents demand ample care in the case of such great locks and no material must be let ooze into the channel from the swamp.

The south approach to the upper lock extends in rock and clay and sand and gravel for some 450 to 600 ft. to the verge of Locksite Cliff. The outer half or more is in the created lake, where the water is 80 to 85 ft. deep. It is considerably over a hundred feet below sea-level to the rock here as demonstrated by various early borings.

These approach piers are, therefore, of formidable height, both to build and maintain. One must reflect that a very considerable on-shore wave may be developed in a lake 80 to 85 ft. deep. These waves may come directly from the south or from winds drawing down the valleys of the Gatuncillo and Trinidad from the southeast and southwest. Therefore, the approaches cannot be gossamer or unreliable structures. When a northern hurricane in Lake Gatun blows against ships great and small, there will be full need of something substantial to moor to or beside. No facilities of this kind are afforded. No side approach piers are contemplated. The central one shown in the Minority Report of "cribwork on piles, 60 ft. wide, over 85 ft. high, capped with concrete," is a rather frail reliance against which to moor a ship 900 ft. long, 100 ft. wide and 60 or more ft. above the water with a hurricane norther blowing on her quarter. Wind is worth considering on this or any lake; ships are worth taking care of here as elsewhere. There seems to be a fundamental proneness to forget the ship for which the canal is built. By leaving most of the south approach in the very deep lake, by setting the north approach walls in the mo-

rasses, by placing the lower lock for nearly its whole length in the "Swamp of the Quicksands" and for its foundations chasing the dipping rock to over 60 ft. below sea level and nearly 70 ft. below the marsh and its jungle-clad edge; by putting the uppermost gate chamber of the upper lock beyond the verge of the volcanic mud-rock-blanket and over "sand and gravel and blue clay," it is triumphantly announced that the Gatun Hill is big enough for three 1,000 ft. locks. The garment of Mother Earth is woefully stretched, no account is taken of the problems of the lake approach, and the safe safety dam is completely sacrificed. This is another story.

Walls Like Those of Pekin.—It is abundantly evidenced by the data in hand that there is safe room for right approaches on both sides to but a single separate set of twin locks, one for up and the other for down traffic. These and these only can be fully embedded in rock.

If one examines Sections 2 and 3 of the upper lock he notes that the walls of the locks extend above the present hill surface as much as 35 ft., and even there are but 5 ft. above the level of the proposed lake.

In the middle lock, in Section 6 they are seen to rise 40 ft. above the present surface. Plenty of back fill here, and again only a 5-ft. water margin.

In the lower lock in Section 6½ the walls tower like those of Pekin, 45 ft. above the plain. But this is not correct. The walls are set by the expert designer 28 1-3 ft. too high! But out of the "Swamp of the Quicksands" they do rise to some 28 ft. Plenty of back fill here again and plenty of concrete also, as from the bottom of the walls to the top is 87 ft. 4 ins. Yet these studies take no account of the probable removal of unsound rock and deeper foundations in consequence.

CHAPTER XVII.

Perils of Locks in Flight.

In the opening paper upon the Lock Tiers it was pointed out that engineers and technical journals desirous of supporting an official Government project had felt obliged to deplore the especial risks incident to setting the Panama locks in flight. The majority of the International Board, it will be recalled, went on record again and again against their menace. The flights "are much more vulnerable than any other essential accessory that has been proposed to be used in any type of canal that has been considered by the board, and this jeopardy has been considered a very grave one."

Such a flight of locks as is proposed here at Gatun is unexampled and unparalleled in the whole existing world. It is, because of its scale, a daring and herculean experiment, to be attempted for the first time in history. These structures, therefore, as to their foundations, their arrangements, their construction and their facility for manipulation should be beyond any question or challenge whatesoever. They should be so entrenched in conservatism and safety that they could stand technically invulnerable—this and this only would give warrant for decreeing unnecessarily an anomaly with no precedent as a guarantee for its success. For all the facts in regard to these two features, the dam and the lock flight at Gatun, centering and compassing the very existence of the canal, one must go naturally beyond the arbitrary ipse dixit of five men sitting upon their own project. Every element of the proposal must be weighed and measured nakedly against incontrovertible evidence.

"Perilously Near Impracticability."—"In the operations required for raising the Ironclads in one series of locks and for dropping them down in another, the difficulty would come so perilously near impracticability that in the opinion of the Board no scheme involving it should be accepted." Such uncompromising denunciations of flights were based upon the fundamental and intrinsic hazard of the system itself. To take needlessly, large vessels and heavy battleships, "the difficulty of handling which in the most favorable circumstances is notorious" up a staircase of three locks all for the whim of men trying to justify and re-establish an

85-ft. canal is surely deprecable. To foredoom great interests to peril superfluously is not of good omen for the waterway. The Commission's rejoinder to this universal foreboding was "There are some people, you know, who are afraid to go up in an elevator." But the Experts, Commission and Secretary of War, despite this outward semblance of confidence, have had themselves very real misgivings. In the Minority Report we find in concession to the drastic condemnation of their confrères this:

"If, however, the gates supporting the summit level should be carried away and the current flow unobstructed through the locks with no means in readiness to stop it, such, for example, as a movable dam, the result would be very serious indeed. It would require many days to lower the level of Lake Gatun sufficiently to render the task of closing the opening through the lock easy, and in the meantime the channel and the works below the lock might be seriously damaged and navigation suspended for weeks or months."

If the "Experts" themselves allow this much the situation must call for serious reflection.

The safety devices for this waterway should be sure, safe and efficient beyond any peradventure whatsoever. The fact which confronts one here at the very start is that this lock flight situation, being unprecedented and unparalleled in the world, its conditions never yet have been tested, let alone proven or safeguarded. The minority realizing, despite their assumed sang froid, that this Gatun Lake simply must be held back at all times, if the canal was not to be itself destroyed, took up the consideration of safety devices. Page 90, Advisory Report, gives the resumè wherein some solution was sought for the momentous situation.

"Experts" Confessed the Danger.—But no instances could be cited anywhere of a device which had been brought up against conditions at all parallel to those obtaining at Panama, or which had ever succeeded in holding back the rush of such a torrent and volume of water as a break of the upper gates would release down this staircase. At the end they left this evasive summary:

"The problem of working out a satisfactory device for this purpose in the deeper channel of the Panama Canal is a difficult one, but no doubt is entertained that a solution can be made; for such appliances the sum of two million dollars is included in the estimate of cost. (Page 91.)

Movable dams at ends of summit level.....	$2,000,000	Page 95
Movable dams at the Gatun and Pedro Miguel locks for stopping the flow from the summit level in the event of the destruction of the lock gates	2,000,000	Page 426

In the above citations it is abundantly evidenced that the Experts did confess the danger inherent in their flight and did recognize the wisdom of providing ways and means for conserving the summit level in event of disaster to the lock gates. But they were compelled to realize, likewise, that whatever was interposed must be experimental for this duty, and that nothing of the types to which they referred gave enough hope or chance to warrant any indorsement. So they simply appropriated money and left the discovery of some available device to the future.

No startling heaven-sent invention has come to meet the need of this lock flight, and the Commission is still only where it was when the Board adjourned, leaving this most crucial feature of the entire waterway, the feature burdened with the very forefront and brunt of the canal's defense, utterly unsolved. They have waited Micawberwise for something to turn up. Nothing has turned up. The question is to-day where it was. How shall the Panama Canal, and the shipping that shall chance to be in its channels between the seas, be defended, if an accident occurs at the gates?

What Are the Defenses?—The lock flight at Gatun, it will be remembered, is interposed in front of a lake 171 square miles in area and 85 ft. high. It is manifestly of the supremest importance that the summit lake be held safely back. Its waters are self-evidently freighted with too imminent a catastrophe to allow any inadequacies as to safeguarding here. What, then, are the provisions for insuring against lock and gate mishaps? What are the appliances for checking back the Gatun waters in case of an accident?

It was figured, it will be recalled, in the mathematic averages that the chances for an accident to a lock gate of the 85-ft. scheme at Panama were two a year. Not forever can good betide and evil be escaped. Sometime, somehow, somewhere, must the human equation tell and the unexpected befall. It may not chance for years; it may await the first ship that mounts the waterwall. What are the defenses?

We consider what safety devices are proposed for Panama. The first measure is not an appliance, but a precaution. Vessels are to be prohibited from entering the locks

under their own steam, or rather the Experts say this is to be the regulation, and the Commission contradict it and have a method of their own, which is to be observed. The divergencies and inconsistencies between the reports make the safety provisions look rather lame. But accepting the good intent and allowing that this additional precaution is to be observed, how does it operate?

From the Senate Testimony:

Colonel Ernst: The boat is pushed forward 80 ft.

Senator Kittredge: How pushed forward?

Colonel Ernst: By capstans or whatever power is used for moving the boat. She is moved forward by her own power or by some other power, probably by capstans.

The "Pushing" Capstan!—We pause and muse upon this "ready relief." Pushing the ship along by capstans! a new invention for Panama the pushing capstan! And was the siesta in this dolce far niente counted into the 13 hours specified for transit of the Isthmus? To "push" and control through three conjoining locks a dead weight of some forty thousand tons will take an interesting system of bow lines and stern lines and breast lines along the staircase. For vessels of large size, this looks like a bit of an undertaking, and certainly to "push" through one vessel would consume no small part of a day. Yet this expert reckoned 25 lockages per diem.

But another denies all this. It is his system which is to obtain. Page 1914:

Senator Kittredge: How would you push it ahead? Would you use a windlass, or what?

Mr. Stearns: Generally it would be by a tug behind it.

"A tug behind it!" This witness is supposed to be building a lock and a canal for navigation. We understand why the commission consoled the public "American ingenuity is not dead." It will be an inspiring sight, a sight worth awaiting through eight strenuous years, to see a tug by pushing behind, work a modern liner through these three beetling locks.

Go down to the water front and watch half a dozen tugs pulling and hauling on an ocean steamer as they work her into berth. They take some sea way, these writhing little sea serpents. A Cunarder 800 ft. long, will not have overmuch space to strut about herself in a lock of 1,000 usable feet. With her nose in the forward gate even, it will be a very tidy fit for the tug. Picture this panting little attendant "pushing be-

hind" against an express steamer to get her up or down the liquid staircase. This is to be the process of locomotion provided for the Panama Canal! Imagine our ten million dollar battleships in alliance with a fleet of Dreadnoughts in some national emergency hurrying through the waterway with a dapper little tug behind each, desperately pushing it to destiny. Is not all this laughter for the very gods? And is the laughter not shot through with amaze that such engineering is upheld and called "great" at Washington? It is such "knowledge" of technique and of navigation which is floating this lock flight and the monstrous dam.

Surely the "prohibition" of "entering under steam" cannot, till some rational expedient is suggested, be considered seriously.

But One Set of Double Gates.—The second safety provision is double gates. These are proposed for the summit level only and refer to but two locks out of six. At least so the Expert testifies.

Mr. Stearns: The inner or double gates that you refer to were placed only on the summit level. Let me take first the two lower locks where there are no double gates.

The two lower locks at Gatun are therefore to go without even this precaution. Gates come within the realm of practical normal provisions and seem at first to promise much. But closer study shows them quite inadequate for the final defense. There will be given presently some concrete instances of lock accidents.

One of these occurred recently on the Manchester. It reads in part:

"The vessel collided with the lock and although she had very little way on her, the impact carried away one of the gates. This set free the water in the lock and the weight of the water above the other gates caused them to give way. The result was, the water in the higher reaches of the Canal poured through the lock. There were 8 or 9 ft. of water in the lock. It struck the vessel like a waterfall and it was only by prompt action of the captain that the ship was saved. He thought it a miracle. "We were practically stopped," he said, "when the boat struck the gate, but the gate was carried away, and the vessel meeting the full force of water coming out of the lock was tossed like a cork. Fortunately I was able to keep her bow on. Had she been struck broadside on she would have been wrecked." Coming from Manchester was another steamer and soon its plight was perilous. At the coal tips a quarter of a mile away a ship was torn from her moorings."

"Saved by a Miracle."—Note of this accident, the particulars: "We were practically stopped." "There were 8 or 9 feet of water in the lock." "The vessel meeting the full force of the water was tossed like a cork." "Saved as by a miracle because she was 'bow on.'" "Vessel a quarter of a mile distant torn from her moorings." "Other gates give way." "Plight of approaching steamer perilous."

One instance of the actual performance of water is worth volumes of theories as to how it ought to behave. If now the water in the lock had had a head of not 8 or 9 ft., but of over 28 ft. and a depth of 68 1-3 ft. there is established one element of comparison. If next, the ship was not the small coasting craft of 700 tons, carrying sulphur ore, but the large ocean liner or battleship which the Panama Canal must be safe to receive, there is instituted a further element of comparison.

A second accident just about a month after the Manchester mishap occurred on the Welland Canal. Here the small steam barge Nipigon found no difficulty in crashing through not only two gates but through five separate gates, and the locks are 240 ft. long. The two Panama gates are separated by but 80 ft., and double gates are incorporated, the expert asserts, it must be remembered, on only the upper lock. Multiply the Nipigon's effect by the ratio of her tonnage to the Carmania's, for example, and the double gates become in an accident almost as futile as paper. The claim is made that a vessel will not be able to run through two gates eighty feet apart. This is mere rash, reckless bravado. A wrong signal, the parting of a cable, the time element for reversing great marine engines and getting the effect of the propellers, and 80 ft. will be covered almost in a breath and the ruin done.

Every Restraint Defied.—The Manchester account reads:

"Ere the gates behind her could be closed she had crashed into the gates in front. The force of the impact caused a terrific noise, and this din was repeated shortly after, for the officials on the spot, seeing what had happened, hastened the closing of the hind gates to prevent the inevitable onrush of water. Quickly as the machinery worked, it failed to achieve the purpose desired. The water in the lock, finding an open course to Liverpool the moment the collision occurred, rushed onward in a seething current on the Manchester side of the lock and forced its way through the hinder gates, defying machinery and every restraint."

SOME RECENT INSTANCES.

"Engineering News," July 11, 1907. A pair of lock gates on the Cornwall Canal, in Canada, were wrecked by a steam barge on July 5. The Montreal "Gazette" reports the occurrence as follows:

"The steam barge Ionia tore two gates out of lock 17 of the Cornwall Canal this evening and thereby tied up navigation. As far as can be learned the Ionia's lines were not tight enough and after the lower gates were closed behind her and the dock was being filled she surged ahead and crashed into one of the upper gates, displacing it. The weight of water on the level tore off the other gate, and although the steamer was given full steam ahead she was carried back by the water and damaged the lower gates which, however, fortunately, held.

In the past dozen years or so its gates have been carried away three times by the steamer Ocean, the barge Kildonan and steamer Hepburn. It is fortunate that the Ionia was not a heavier craft else the lower gates would surely have been wrecked, and perhaps lock 16 as well."

Still another:

"On June 3, 1907, between three and four o'clock in the morning, occurred an accident to Lock No. 30 of the Erie Canal, at Fort Hunter. A westbound tow, consisting of two loaded boats, ran into the lower gates of the longer lock. The lock was full at the time and the upper gates fully or partly open. The report is that one gate was closed. The impact of the boats with the gates caused the latter to partially open and, consequently, permit the water, under a head of 10.6 ft. to rush between them and against the boats. This rush pushed the boats backward and closed the gates, but these latter did not stop at the miter but were crushed and continued to swing down stream.

The blame is laid upon the boatmen by the lock tenders, and by the former upon the latter. It was deemed fortunate that one of the upper gates was closed and the spud of the other up. Why one gate was closed is not known. Had both upper gates been open and the spuds down, in other words, had this lock been ready for a downstream fleet, the catastrophe would have become historical upon the Erie Canal. Practically the entire volume of the fourteen mile level would have passed through this lock and, as the lower end of the short level below is in embankment, it would have washed out. The extent of such an accident would have been disastrous."

It becomes apparent, therefore, that the conservation of the Gatun summit level must depend upon some other provision than lock gates 80 ft. apart. This brings the review to the consideration of what special appliances, tested and proven in actual service upon other canals, are to be incor-

porated as safety devices for holding back the Isthmian lakes in case of accident to the lock gates.

Manifestly the menace is too imminent and too appalling in possibilities to be chanced upon the experimental, as is so much else upon this luckless Panama Canal.

Safeguards of Summit Level.—It was shown from the concrete instances of the four latest canal accidents that gates 80 or so feet apart afforded no adequate security for conserving the Summit Lake Gatun at Panama. A small ore carrier of 700 registered tons on the Manchester struck a gate, the impact wrecked it and "the other gates gave way." The steam barge on the Welland swept through five gates before she could be halted, with locks each about 240 ft. long. This was the fourth accident on the Manchester within ten years; in each case the gates had been dangerously rammed. All four of the cited canals are relatively small. The craft colliding with the gates were small and the locks on the Manchester are separate. It becomes conclusive, therefore, that the Panama Canal must be safeguarded by something very much more formidable than doubled gates.

CHAPTER XVIII.

Lock and Lake Safeguards.

We turn, therefore, next to examine what safety appliances are to be incorporated for insuring the waterway and the world's shipping against the down rush of the two Panama lakes, Gatun and Sosa, in case of accidents at the locks.

The first lock defense originally proposed was right approaches. The minority experts themselves wrote:

"The approach piers, the extent of which greatly affects the safety of a lock, are excellent at the St. Mary's Falls Canal, and far better than at any other ship canal and doubtless have contributed to the remarkable record of immunity from serious accidents.

The canal construction should provide long approach walls at each end of every lock or flight, so that the ship can be held under perfect control. For this important purpose a long solid pier is vastly superior to mooring piles and floats, such as are used in some foreign canals. The apprehensions of some members of the board may be due to the fact that their experience has been entirely with canals having this radical defect."

Right Approach Walls Abandoned.—After thus specifically pointing the radical defect of approach walls which are not "solid," and after entrusting much of the lock safety to the right approach constructions, they abandoned solid concrete approaches and substituted "crib work 60 ft. wide, 85 ft. high, on piles driven in soft clay and the cribs capped with concrete." When the formations in Gatun hill were supposed to be adequate for right accessories, solid approaches were advised. But the discovery of the facts at the site compelled the reversal of the saving decision. The first defense of the locks went when the rock foundations dipped out of reach.

The safety of the canal and the ships was sacrificed to the fetish of the flight.

The location of safety devices in general relatively to the lock is the next important element. These appliances may be inserted within the upper lock or beyond the lock. If within, the chances of securing the end sought are so very much lessened that such an adjustment should not be tolerated. Yet most of the appliances thus far considered by the experts of the board seek to conserve the summit level by

means of devices located within or just outside and adjoining, and for the best reason in the world, as will soon appear —they have no foundations in the site for a right safety dam where it should be placed. Adequate defense of the 85-ft. canal is therefore fundamentally forfeited by the adoption of a flight of locks.

Let us examine the conditions surrounding inner devices.

From the upper water surface to the bottom of the upper lock is 85-16.67 ft. or 68.33 ft. The depth to the upper miter-sill, at 45 ft. above sea level, is 40 ft. The lock and gate width is set in the last official section drawing at 100 ft. (it ought to be more, as has been shown); southward of the gate is the lake.

Locality Most Exposed to Danger.—In case of disaster a column of water 100 or more ft. wide, 40 ft. deep over the upper miter-sill and 68⅓ ft. deep in the lock, will have a fall of about 28⅓ ft. if the middle lock is full, or double this, 56⅔ ft., if the middle lock water is at its low level. Since the water plane in the lake may be from 28⅓ to 56⅔ ft. higher than in the middle lock, the surface of the rush in the escape will be a succession of vertical curves, with the steepest inclination nearest the upper gates and the most violent currents must be created, manifestly, in the upper third of the upper lock and just inside and outside of the section occupied by the double gates. These defenses therefore are perforce at the heart of the tumult which they are expected to halt. Hence this locality is the very worst, and the one most exposed to danger and contingencies, so safety appliances should not be set in the lock or close to it. Yet this is where the newest proposition is to put them.

The Commission's safety device must be taken to be located in the upper lock or adjacent to it, since the position of the upper gate chamber was fixed by the designers on the brow of the hill, and the official plate shows nothing lakeward of the lock save the clay-floated approach pier. But this is manifestly an impracticable position amid such ferocious rapids, and one unsafe from broken gates, or from vessels plunging from the lake level into the lock.

Manchester Accident a Warning.—Not only is a vessel which may overrun a gate in danger herself of jamming in the lock as did the Cassia at Irlam on the Manchester, but the currents induced by the disaster will assuredly tear craft mooring along the approach and bear them to ruin, which

would be most apt to prevent the working of the safety device if it be placed inside the lock or just adjoining. It will be recalled in the Manchester mishap the rush of "but 8 or 9 ft." of head started the mischief, which speedily tore a vessel from its moorings a quarter of a mile away. In the instantaneous onrush of water through a breach and the carrying with it of the ships of whatever size that shall lie in its path are nice courtesies likely to prevail? Will these ships avoid being directly in the way of the safety devices ensconced so carefully in the lock or just outside? How are they, crashing downward, to get out of the way in order that the devices may hold the lake? The only safe place for a safety dam is well clear of the lock itself.

The next thing to be considered is whether or not at the various lock sites there is room sufficient, and far enough outside, for whatever device is applicable. At Pedro Miguel with its single lock there is room. Review is necessary, therefore, of the conditions at the Gatun and the Sosa lock-ladders only.

At Gatun there is this situation: a dam over permeable and artesian strata holding up a lake elevated to 85 ft. and about 171 square miles in area; a flight of three twin, 1,000 ft. locks, founded partly in a sheet of solidified volcanic-mud and partly on "sand and gravel," "blue clay," "clay and sand" permeable to waters of the proposed lake. On the west side of the lock walls, which rise for much of their length to 40 ft. or more above the present surface of the hill, is the great dam On the east side is another section of the dam and two deep ravines, which almost cut off Locksite Hill from the steep main ridge of this Gatun spur. In the north ravine adjacent to the locks in bores Nos. 362, 359, 537, 542, 541, 539, 531, 544, 530 and 529, it is revealed that the volcanic-mud-rock line dips suddenly and is covered with surface clays to a depth of more than 110 ft. This sufficiently demonstrates the impracticability of moving the lock axis either to the west or east. On one side are the Chagres valley and the Gatun geologic gorges, and on the other are these deep ravines with the wrinkled rock surfaces far below the bases of the lock walls.

Safety Dams "To Be Discovered."—With this surveying of the ground, it is manifest that the only change possible in lock location at Gatun is one north or south along the selected axis. But if the locks (see profile) are moved north-

ward, the foundations must follow the dipping sheet of caked, volcanic-mud-rock deeper and further into the morasses of the swamp of quicksands. If the locks are moved southward, more of the upper lock becomes poised over the 70 ft. of "sand and gravel" of Locksite cliff. It is, therefore, practically impossible to improve the actual lock location of the flight as shown on the profiles.

The safety dams "to be discovered" and about which "no doubt is entertained" (although in no canal in the world could their proposers succeed in paralleling them) concern at Gatun, as the Senate testimony recorded, the summit level only and two locks out of six.

Nothing, it will be remembered, has been provided or estimated for the safeguarding of Lake Sosa 65 ft. above low tide.

The experts in considering means for checking the rush of water in event of the summit lake's breaking loose through an injury to these lock gates noted particularly two appliances.

A Device of Forty Years Ago.—One was a safety arrangement, a device installed forty years ago on the St. Mary's Falls canal, then removed without having stood the test of any actual trial. "More than forty years ago a pair of gates with powerful brakes to check their movement while closing in a current were placed about 3,000 ft. above the locks in the St. Mary's Falls canal. The gates were removed about fifteen years later when the canal was deepened." This device, it is to be noted, was located in accordance with the right safety principle. It was set 3,000 ft. above the lock, not within or near it. The depth of water in the canal was in these early days slight. In 1855 the Soo passed craft of 12 ft. draft only. The Soo locks are to-day of but 20 ft. depth. Its waterway is used chiefly by the ore and coal carriers of the lakes. These ply their same route back and forth through all the open months of the year. Captains and crew grow intimately familiar with the lock passages, and owing to the very simple and favorable conditions the Soo has had one of the least eventful experiences of lock accidents. The Majority were at pains to point out how different was the whole situation at Panama from this oft-quoted Sault Ste. Marie. The device of forty years ago evidently did not highly recommend itself to the management, for "when after fifteen years the canal was deepened,"

the "pair of gates provided with powerful brakes" are abandoned and there is installed next against the increased depth a "construction consisting of wickets, each so small that its movement could be controlled by machinery of moderate power. The wickets were carried by a swing bridge and when not in use the bridge was open and the wickets were then on land, where they could be inspected and repaired. The canal force was trained regularly in the handling of this device so that they might work efficiently in case of actual need. For such experimental practice, the same procedure was followed as in a real emergency, viz.. the bridge was swung across the canal and the wickets lowered one by one, their lower ends resting against a sill at the bottom of the canal, the upper ends supported by the bridge."

Must Panama Go Undefended?—It will be noted that the simple conditions of this interlake canal passing little more valuable than ore and coal carriers, a canal where the world's battleships are not at stake and the "largest vessels afloat and those which may reasonably be anticipated" have no coming and no going, have yet been deemed in need of adequate safeguarding, and constant drills have been considered right and precautionary. If the risks even here are of a quality to demand thus much watching, what are they at the Isthmus? But Panama—Panama, with everything against her! She must go quite undefended against her Lake Sosa and at Gatun two only of her six locks are to have so much as a pretense of safety. In her two privileged locks, even, she must lean on the reed of the untried—and as will be seen—the unavailing.

After eighteen more years the Soo is again deepened. Is the old wicket device again installed? No. Ships of 16-ft. draft were passing next in 1881, but that appliance had not had a chance to prove its title clear against the small waterfall. The increased width and depth called for additional security. The second device of wickets is removed and a "modified form" is to be tried for the third stage:

"A modified form of the device was built at the Canadian Canal at the St. Mary's Falls, but is yet untried, and another is about to be supplied for the American canal."

Situation Quite Beyond Them.—These two proposals of "gates with powerful brakes" and "wickets" are therefore experimental only. The first was abandoned for even the very low head of the Soo and the second is to be "modified."

They are not certainly to be considered as tested and proved, and therefore available against the 85-ft. lake at Gatun. They are not the solution on which to venture three locks in flight on the Isthmian canal. Yet, at this point, having detailed the appliances unproved against the low fall in their little world, between Lake Superior and Lake Huron, both sides, Canadian and American, the Minority and the Commission all rest the case. Their final word on the subject is this:

"The problem of working out a satisfactory device for this purpose in the deeper channel of the Panama Canal is a difficult one, but no doubt is entertained that a solution can be made. For such appliances the sum of $2,000,000 is included in the estimate of cost."

What is to be said of such treatment of this most momentous problem, burdened as is seen with the very brunt of the canal's defense, taking and holding the shock of a loosened lake starting its riot down the staircase? It is manifestly an open surrender, a confession that the situation is quite beyond them. While not citing or recommending any known method which has visually demonstrated ability to control an emergency rush through a lock, and while offering no solution whatever themselves, they yet profess entire confidence that something will turn up. On this go-lucky basis would it not be criminal to rest a final assurance of the safety of a flight of locks holding at such stake, life, property and the country's honor?

No Such Menaces Anywhere.—The Commission finding that the profession was not to be narcotized by lulling assurances have lately bestirred themselves to solve the problem which the experts thus nonchalantly laid down. In a delirium of engineering the Government was projected into a totally unnecessary 85-ft. lake. A monster dam has been designed to hold it up and a colossal flight to reach it. Such menaces have never before been incorporated anywhere. When actually confronted with such creations it must be recognized that no human appliance has ever before been called to face the sudden disaster thus untowardly lurking and prepared. Facing these facts are the hazards modified and the elements brought into the realm of rational safe provision? No, the whole situation is just dropped and the report announces "No doubt is entertained that a solution can be made."

The wider one's experience, the deeper his respect for the power of water. Water is a father of giants and no one can wisely wake its sleeping strength.

However, it is the supreme purpose of these papers to help, not hinder. They condemn only in the hope of lifting the canal from its present plight. Does any method exist that could be savingly applied here?

Deprecating the whole 85-ft. situation and the deplorable treatment of this vital feature and interest, we survey the possible methods and the reported later studies for the control of the lake levels. We will examine briefly what the experience of the world has evolved to meet allied emergencies.

The examination of the environments and conditions at the Upper Gatun lock demonstrated one supreme fact. In event of the carrying away of lock gates, safety devices, either within or adjacent to the upper end of the lock, would be in the most adverse position possible, and therefore should not be thus located. The only right place for a safety device was shown to be quite away from the lock it must defend. The devices suggested for the situation at Gatun and the other possible provisions are next briefly reviewed:

Minutes of One Hundred and Fourteenth Meeting.—Washington, D. C., Sept. 6, 1906.—Present: Chairman Shonts, Commissioners Endicott, Hains and Harrod, and Secretary Bishop. Mr. Joseph Ripley, principal assistant engineer, in charge of the preparation of plans for and the construction of locks and regulating works of the canal, sat with the Commission by invitation.

Resolved, That the chief engineer be requested to consider the advisability and practicability of constructing a basin with walls and gates at the head of each lock or flight of locks, in which basin the lake level will be maintained, and all vessels stopped before entering the chamber of the lock, and furnish the Commission with his recommendations and estimate of the cost of same.

Basin Works Impracticable.—This is a serious formal proposal that the approaches to the locks from the lakes be encircled by some great basin works, suggesting dimly the historic colonnades inclosing the plaza before St. Peter's in Rome—with an outer gate as warden of the flight. It will be recalled from the profile of borings that there are no reachable rock foundations whatever for such a scheme in the lake at Gatun, and it is thereby made wholly imprac-

ticable. The walls and gate of such an imperial court must not only be watertight, but very strong, because if the basin were emptied in a lock accident they might be called upon to withstand the 85-ft. lake, and such a court must needs be far larger than a lock, and its incident concrete works much more massive and formidable. The lake a few hundred feet from the upper lock chamber would be 80 ft. deep, and bores show that it is over a hundred feet below the present swamp to "clay rock" a ship's length away.

Heretofore movable or safety dams have had relations chiefly to low summit heads. They have had a long and interesting history. They have been called into service almost exclusively for insufficiencies where navigation becomes impracticable from the shoals of the low water periods in rivers; these appliances temporarily dam the waters to afford flotation to logs or to river craft, and they have assumed various forms.

Needle Dam Unthinkable.—In 1834 M. Poirée installed one of the earliest examples of the needle dam on the River Yonne in France, and the type was later applied to many streams in France, Belgium and Germany, but always to secure relatively slight increases of depth from 7 to 16 feet. Hollow needles instead of solid have been proposed and two tiers of needles to deal with higher heads, but they are still practically untried. The needle dams of the Meuse support but 10.17 ft. In the Big Sandy at Louisa, Ky., the pool is 13 ft. above the sill. There are various modifications of the needle dam, and improvements have been invented by Boule, Chanoine, Janicki and others. But what is applicable to small heads becomes more mechanically cumbersome and difficult with each increasing foot of depth, and this not in a direct proportion, but with an ever higher ratio, until for depths of 40 ft. and a head of 28 1-3 ft. and a width of over a hundred the mechanisms assume such formidable dimensions and the adjustments become so necessarily slow that the needle dam in any of its modifications and all the other allied types involving the same general limitations become simply unthinkable for meeting the Gatun emergency. Yet the authorities are described by the well-informed Scientific American as canvassing several of these impracticable devices to be inserted within the lock or immediately adjacent to it. They are driven to these futile dependencies, not because an adequate device does not exist.

but because this flight and the site rule out right protection. One must recognize that the basic limitation of canal defense for the 85-ft. is set in the fact that the enforced position of the upper lock at Gatun is such that devices which occupy any material length southward along the lock axis and safely away from the lock gates are absolutely precluded.

Other Devices Will Not Answer.—To continue the roll of summit upholding mechanisms that the general range may be covered—there is a curtain dam, a device like a roller window shade, which can be applied to shallow depths and low heads, but which is likewise impracticable for high heads and great depths and widths. The frame to carry it would cut off navigation. Then there are such appliances as the Poses dam on the lower Seine. This is likewise impossible of adoption for the above reasons and also because it, too, would preclude navigation.

Next there are the shutter dams of various types, with the turning axis of the shutter at different points, bottom, top or in the center like a stove damper. Also, the wicket dam of America. These likewise are for low heads and shallow pools; that at Port a Langlais on the upper Seine deals with but 9 ft. 10 ins. of water, the Kanawha with but 10.87 ft. They are unproved, as was shown, against even the low fall of the Soo.

We have the Krantz pontoon dam, another low head design; the Girard shutter dam, in which rams raise the shutters or wickets, still another low head affair. Next in line comes the horizontal drum dam of 1846, and its improvement by Cuvinot and Chittenden. The latter's design was applied to a difference in levels of 16 ft., but the drums made up only 7 ft. of this; 9 ft. were permanent.

Then there is the rolling cylinder movable dam and the drum of various shapes rotating vertically or horizontally, all again for low heads.

Irresistible Liquid Avalanche.—This passing analysis of the leading types of movable dams shows the ends to which they are adapted and which alone they have met. The water wall of an escaping lake 100 ft. wide and 40 ft. high starting down a chute of 85 ft. is such a liquid avalanche as to be quite utterly irresistible by any of these appliances. They would be in it as very thistle-down.

The Bear-Trap Dam.—This brings the review to the last type—the type which the Commission has not planned to

incorporate—the American bear-trap dam. The invention of the American bear-trap dam is set forth in Wegman's standard work on the "Construction of Dams":

In 1818, Josiah White, Philadelphia merchant, and Erskine Hazard, the managers of the Lehigh Navigation Company, commenced the improvement of the Lehigh river to obtain slack-water navigation for transporting anthracite coal to market. At the first the improvement consisted only in the construction of wing-dams, but this did not furnish the minimum waterway required by the charter of the company, viz., a width of 25 ft. with a depth of 18 ins. White and Hazard had, therefore, to seek other means of increasing the depth of the water. They determined to accomplish this by producing artificial freshets by means of some kind of movable gate which was to be placed across the river. White spent several weeks in trying to construct a satisfactory device for this purpose, and finally produced the well-known bear-trap gate. He built a small gate of this character in the Mauch Chunk creek which excited much attention during its construction. The workmen employed tried to rid themselves of curious people, who wished to find out what Mr. White was constructing, by telling them that it was a "bear trap," a name the gate has borne ever since. In 1819 twelve dams having gates of this kind were placed in the Lehigh river, and proved to be quite successful. Later on this gate was used on the logging streams of Pennsylvania and Canada.

One of the first engineers to revive interest in the bear-trap gate was the late Ashbel Welsh, president of the American Society of Civil Engineers, who, in his annual address delivered to that society in 1882, stated:

"The bear-trap locks (White's on the Lehigh) have given the hint for several devices since used, and are all well worthy of an examination."

"It is worth inquiry whether these bear-trap gates would not be the best possible, and possibly the cheapest, for letting the water rapidly out of a reservoir for scouring purposes. A full stream could be set running in a few seconds, and the flow could be regulated with perfect ease and stopped at any moment."

Is There Room for the Bear-Trap?—Since then it has been very generally and very successfully employed on large works.

Here is the one type of dam which gives real certainty of success. It is the only safety device for Panama. It is beyond any peradventure the appliance alone suitable or practicable for the situations at Gatun and Sosa. Is there room for it? We shall see. An account set forth from accurate information afforded in Washington to the Scientific American appears in its issue of December 8, 1906, from which we quote:

"The Commission engineers are making a scientific study of various devices by which, should the gates be broken down, a barrier could be interposed back of the gates at the entrance to the locks which would close the entrance and hold back the water. There are three principal methods under consideration. First, the use of huge caisson cylinders which could be floated across the lock entrance and close it in much the same way as the caisson gate closes a dry dock; second, the use of an emergency swing bridge carrying vertical gates, and third, the use of a special type of hinged swinging gates.

1.—If cylindrical caissons were used, they would be placed either horizontally or vertically. In the horizontal system a cylinder 46 ft. in diameter, which is the depth of the water in the lock entrance, and slightly longer through its axis than the width of the entrance, would normally lie in a transverse sunken pocket, built transversely to the axis of the lock, and sufficiently deep to allow the cylinder to lie submerged below the 45-ft. level. Should a lock gate be carried away, this cylinder would be rolled up out of its pocket on an inclined plane, until it rested upon the bottom, with its ends bearing against suitable shoulders built for this purpose in the side walls of the entrance. As the cylinder would be built with a diameter slightly greater than the depth of water in the entrance it would serve to effectually close the channel and hold up the lake level until repairs had been effected. The rolling of the cylinder, which would be water-ballasted sufficiently to give it a slight margin of submergence weight, would be done by means of heavy cables passed around the ends of the drum and operated by powerful winches suitably placed on the shore. Another plan under consideration contemplates the use of two vertical cylinders, which normally would stand in vertical pockets formed in the side walls of the entrance. Each cylinder would be slightly smaller in diameter than the width of the entrance so as to secure a slight resultant horizontal pressure when they close, and provision is made for swinging them out of their pockets until they meet at the center of the entrance channel, where they would form a barrier to the flow of water.

2.—Another method contemplates the use of two vertical sectors of cylinders hung on heavy pintles at the side walls of the entrance and normally swung back into pockets out of the way of the traffic. Should a vessel collide with a gate and be sunk in the channel, these gates would be swung shut until they met or closed against the sides of the sunken vessel. The advantages of this type of gate is that as the resulting thrust is normal to the curved upstream faces of the gates, there would be no destructive impact as they swing together in the face of the rush of water.

3.—Another method of holding back the lake would be the provision of a swinging bridge, mounted on a turntable

and corresponding in its construction and operation to the ordinary swing bridge over a navigable waterway. In case of accident, one arm of the bridge would be swung across the 100-ft. opening of the entrance until it brought up against an abutment formed in the opposite side wall. From the bottom of the arm, which would be a steel truss of great strength and rigidity, would project a series of vertical steel guide pickets, reaching down the full 45-ft. depth of the entrance, and bearing on a bottom sill. In case of accident, this arm would be swung across the entrance, and a series of steel curtains would be lowered until the flow of water was entirely shut off."

Nine months have elapsed since in February, 1907, this analysis was published. During the interval the designing staff has been constantly at work on this problem. Though twenty-three projects have been studied none has given warrant for selection.

It is apparent that many alternatives have been canvassed. The whole gamut has been run, save only and always the one effective defense, the bear-trap dam.

Five Niagara Whirlpools in One.—First is the huge caisson cylinder, 46 ft. in diameter and over 100 ft. long, buried in a pocket of concrete founded in the "sand and gravel" which extends down to sea-level at the upper lock—a Gargatuan barrel, which on that fateful day when a ship goes crashing down the staircase is to pop up like a Jack-in-the-Box and save the lake. Would any one propose thus to check the whirlpool rapids at Niagara? Yet they have a smaller fall. The lock flight rapids at Gatun or Sosa may have from two to five times the rate of drop which obtains in whirlpool gorge before the mechanism can be set.

The fierce and tumultuous currents of the Niagara whirlpool are caused by a fall of 52 ft. in a mile or one foot in a hundred. According to the U. S. surveys, the whirlpool rapids are 35 ft. deep. The whirlpool itself is 150 ft. deep, the whirlpool outlet is 50 ft. deep. At the foot of the center of the Horseshoe falls, the caldron is 150 to 200 ft. in depth. The fall at the Gatun lock flight is 85 ft. in a distance of about 3,400 ft., roundly a fall of one foot in forty or two and a half times that which creates the most famous rapids in the world. There may be a fall from Gatun lake into the middle lock of 56 2-3 ft. in 1,100 ft., or one foot in twenty, which is five times the rate of fall of the whirlpool rapids. The depth of the torrent is greater at Gatun than at Niagara's whirlpool rapids. The resulting velocities right

where these speculative safety devices are contemplated are sufficiently indicated.

They will be crucial moments those before the locks melt in the ferment of the maelstrom in the "Swamp of Quicksands."

But there is still another double-barreled alternative. Two such are to swing out from vertical pockets and meet midstream to save the canal. They would be about as useful as an umbrella in a cyclone. A 500-ft. "city" liner struck the James and Mary bar in the Hougli river, turned over and was sucked down to the last vestige in only a 7-knot current over its whirling sands. This illustrates the power of water in motion.

"Pushing Capstan" Matched.—Then there is that other "lock and lake saving device," "two vertical sectors of cylinders hung on heavy pintles at the side walls of the entrance and normally swung back into pockets and out of the way of the traffic. Should a vessel collide with a gate and be sunk in the channel, these gates would be swung shut until they met or closed against the sides of the sunken vessel." Oyez! Oyez! Mariners! The very spot is fixed where your ships shall sink in the channel, and "sectors of cylinders" are in the designing room of the Isthmian Commission to fit equally liner and tramp and whaleback, torpedo, cruiser and battleship, on even keel or heeled, whole or shattered. Pushing tugs, pushing capstan and universal mandibles! There is neither voice nor language to do fit homage to these picturesque conceptions.

Then there is the untried "Bridge of Size," carrying an array of curtains and needles or wickets to discourage the whirling rush. Why are such speculative devices proposed? Simply because there is no room for the right, for the real American thing—a bear-trap dam.

A bear-trap dam requires a certain bottom length. To install one here requires at least two hundred and fifty feet. A safety dam ought manifestly to be itself in the safest position. The safest position is not as was shown in the lock—a broken gate, or a vessel, may be directly over it. The position just above the upper gate is yet more hazardous, for right here a ship torn from moorings would most likely jam. The safest position, per se, is about a ship's length clear of the upper lock—say one thousand feet away. This brings the safety dam well clear of the powerful suction

currents of the sluices of the upper lock. The safest place for the pivot of the great horizontal leaf is here, one thousand two hundred and fifty feet from the open gate. But already this upper "official" gate of the lock flight is through and under the rock in Gatun hill, so that the end of the lock chamber at the bottom is seventy feet above the second rock line of the last profile.

Abutments 86 Ft. High.—The data available at this point show that from the pivot axis of the leaf to the rock-line would be apparently 86 ft. A bear-trap dam here, therefore, would have to turn on towerlike abutments 86 ft. high. The device would have to rest when not in use upon a 250-ft. bed whose supports would be 70 to 86 ft. high above the rock.

Not only this, but, besides, there must be either two such bear-trap dams (as the locks are in pairs), one each side of their single central approach pier, which is to be built, as the testimony shows, afloat on clay, in 85 ft. of water, "of wooden cribs capped with concrete," or the dam must have one leaf 260 ft. wide, between an extension of the lock walls. The official drawings give no such extension. The gate chamber is shown already overhanging the rock of the Gatun cliff.

The closest that the "safety dam" could be placed is 300 ft. from the open upper gate—a very risky position, as we have seen.

Such conditions, if safety devices holding any hope in emergency are to exist, must force the flight bodily northward and must lengthen the chamber for the whole "flight" mechanism. The chief engineer hastily certified to nature's favor for a three-lock flight, saying that not only 3,136 ft., but in one place 3,800 ft. were available—"enough for three locks, each 1,150 ft." Did he reckon on a safety dam and the bed and space it must occupy? Such length as 3,800 ft. even was found only by advancing into the Chagres marshes north of the Gatun ridge. When a safety dam of the bear-trap type is incorporated the lower and middle lock both will be perforce clear of the hill and all in the marsh.

Safety and Sanity Sacrificed.—This is the ideal site! As the profile will clearly show, such a readjustment of the locks must vastly affect the whole design and make the amount of concrete to be placed and the cost simply stu-

pendous. For everything safety and sanity must be sacrificed to retain the three-lock idea.

If a safety dam is to be installed to accommodate with the minimum risk of a quite preliminary character the three-lock-flight scheme, including the safety approach and bed for the dam, demands a site of [illegible] the locks plus [illegible] a single [illegible] plus [illegible] the dam, equals 4,[illegible]. The profile shows that such a site does not exist at Gatun. The north approach locks, lower lock and much of the middle lock are already in the swamp, and this would put the flight another eight of a mile swampward.

The site is short, the distance is millions short—the whole business is a short-sighted piece of deliberate and disastrous folly. The rock sill of the Gatun dam is wide enough and thick enough for the lock and no more, with the pharmacy of safety from the approaches and safety devices. The lock flights here cannot be protected. The Summit lake is the Damocles sword. When it fails there will be nothing to avert the ruin.

We have passed in review the provisions made or possible to be made in the locations existing at Gatun for protecting shipping and the canal itself against disaster in event of an accident to the lock gates. It has been seen that the one and only principle which would give safety of availing nature be incorporated and the Government project because the necessary foundations are lacking. Other appliances give no warrant of adequateness or any promise of success. To erect the defense of a Gatun lake to stem is to stem a whirlpool with a reed. When in this light canal the hour strikes for the inevitable accident, it strikes at Gatun and at Soo, lake levels whose defenses are impotent.

The majority of the International Board figured the mathematical frequency of lock accidents for Panama, with six locks, making one for as a basis at two a year. On the Manchester the experience has been less fortunate both as to number and seriousness, so that of the English canal serves as a basis, Panama's chances are materially lower. The majority's estimate considered intervals of time and number of locks alone. But there are several other elements which increase the hazard at Panama. The Soo is closed during nearly a third of a year and the Soo and the Manchester are both in temperate zones where mind and body have their highest efficiency. At the Isthmus the

vitality of men is reduced, alertness and initiative are at their lowest. Lock tenders, watchmen and pilots will suffer the same effect of climate as the employes of the Panama railroad and canal. The capacity for rising to emergencies with quick, accurate judgment and activity will be lessened to a point of inertia increasing the hazards.

Add further, in estimating the frequency of accidents, that a much larger and hence more weighty and less easily manœuvred class of ships will use the Panama canal than the steam barges, coasting vessels and small craft which largely use the Soo, the Manchester, the Kiel and other canals.

Accidents are, therefore, at the Isthmus certain and inevitable. When the casualty shall befall and how and where cannot be predicted. But just as of the ships that go down to the sea a certain per cent must be lost, so of the ships that pass at Panama some must mistake and misbehave, and the trouble be wrought.

History of Lock Accidents.—It becomes evident, therefore, that if on the Isthmus casualties were to be held to even the average of the small waterways, very extra precautions must necessarily have been taken and the most perfect and most effective safety appliances have been provided. With accidents certain and inevitable and natural drawbacks so multiplied there should have been no further handicapping that was at all avoidable. Unnecessary levels and flights might at least have been eliminated.

The nature of a lock accident and its results are more readily understood in the actual than in the abstract. Local accounts are inserted of two only. These are selected not because they are by any means the most significant, but because they happen to be the most recent. Lest mishaps be considered things of back history, occurrences of recent dates are detailed. The first befell on the Welland, the second on the Manchester.

"Ogdensburg, July 23, 1906.—Navigation through the Welland Canal will be stopped for several days as a result of the steamer Nipigon of Ogdensburg carrying away five gates. The cause of the steamer running amuck in the locks is attributed to the engineer making a mistake in the bells, giving his engine full steam instead of backing, as he was signaled to do."

Five gates carried away before the steamer could be controlled! Five gates—and the steamer of the small lake type.

Accident on Manchester Canal.—The Manchester Guardian of June 22, 1906, has the following:

"Shortly after 8 o'clock last evening a serious accident occurred at the Irlam locks of the Manchester ship canal—the most serious that has occurred since the canal was opened. The steamer Cassia, a vessel of about 700 tons, bound for Manchester with a cargo of sulphur ore, reached Irlam locks in charge of a ship canal pilot, and for some reason that has not yet been given made for the large lock that was being filled for a steamer outward bound, instead of the smaller lock, which was in readiness to receive her. The vessel collided with the lock and, although she had very little way on her, the impact carried away one of the gates. This set free the water in the locks, and the weight of the water above the other gates caused them to give way. The result was that the water in the higher reach of the canal poured through the lock.

The Cassia had a narrow escape. There were eight or nine feet of water in the lock. It struck the vessel like a waterfall, and it was only by the prompt action of Captain Olgan that she was saved. In an interview last night, the captain said that this was the first time that he had been up the ship canal, and he had left the entire control of the vessel to the pilot. He thought it was almost miraculous that the boat was saved. "We were practically stopped," he added, "when the boat struck the gate, but the gate was carried away and the vessel, meeting the full force of water coming out of the lock, was tossed like a cork. Fortunately I was able to keep her bow on. Had she been struck broadside on, she would have been wrecked. A large vessel was coming from Manchester to enter the same lock, but luckily she was some distance off. The rush of water was felt for a considerable distance, and at the coal tips a quarter of a mile away a ship was torn from her moorings."

What Lock Wreck Means.—In this connection a representative of the Manchester Guardian wrote:

"A visit to the lock early this morning establishes the fact that for a week at least all traffic on the canal must be at a standstill. In the Irlam lock the water is 16 ft. below the normal level; the muddy bottom is in many places exposed, and an abominable stench fills the air; gangs of men are busy preparing for the work of repair, and up till a late hour Mr. J. K. Bythell and other officials of the Ship Canal Company were directing affairs. Everybody able to give information was pledged to secrecy, but certain facts were obtainable. When the Cassia entered the lock, Manchester-bound, she was traveling at normal speed for such a waterway, but from some unexplained cause maintained her headway, and ere the gates behind her could be closed she had crashed into the gates in front. "The force of the impact," said one who was near, "caused a terrific noise, and this din

was repeated shortly after, for the officials on the spot, seeing what had happened, hastened the closing of the hind gates to prevent the inevitable onrush of water. Quickly as the machinery worked, it failed to achieve the purpose desired. The water in the lock, finding an open course to Liverpool the moment the collision occurred, rushed onward in a seething current, and the volume of water on the Manchester side of the lock forced its way through the hinder gates, defying machinery and every restraint.

"The Cassia cleared the gates she had destroyed, but landed on the lock sill, and close by she now remains. The damage to her bow is slight. Coming from Manchester was another steamer, and soon its plight was perilous. The water in the lock is at ordinary times 16 ft. above the level of the water on the Liverpool side of the damaged gates. Very soon the 16 ft. were reduced to a dozen, and then the muddy bottom of the canal became visible, and the steamer was high and dry. For a time the captain expected his vessel to turn turtle, and he was powerless to do anything. Fortunately she swung across the canal, and as the lock emptied the vessel was propped up to prevent her taking too great a list. For some days she must remain for all practical purposes a steamship on dry land, shored up to keep her on even keel."

The stretch of canal affected by the disaster is from two to three miles long. Fortunately, the tremendous onrush of water from the higher to the lower level caused no further calamity.

The Ship Canal Company propose issuing to-day an official statement as to the causes of the disaster. Meanwhile gangs of men, with every possible appliance for quick repair, are being organized for the rectification of the damage. It is intended to work night and day, and it is hoped that in about a week the canal will be again open for traffic."

This was the fourth accident upon the Manchester canal in ten years. Each of the other three also resulted from dangerous collisions with the gates. Yet locks here are separate.

In twelve years on the Cornwall Canal in Canada the gates have been carried away three times.

The Peril at Gatun.—With such a showing and behavior as are recorded in these two accidents just a month apart on the Welland and Manchester, it is in order to examine what occurrences similar to either one would entail at Panama with locks not single and isolated as were the latter, but in flight.

What of the lock ladders at Gatun and Sosa when the inexorable mathematics of mishap bring a steamer crashing through the gates? The conclusion is beyond challenge.

At Manchester in the last accident it was a small vessel with but 1,500 tons of cargo that wrecked the two gates. At Ogdensburg it was a small steamer of but 700 tons that crashed through five gates. The former vessel landed on the sill and the short level was quickly emptied. What will be the commensurate consequences of a vessel with 40,000 or 50,000 tons going through an upper gate of the Gatun flight from the great lake? There is no room, as was seen, for a safe safety dam.

A Sweep of Disaster.

Should the lower gate, say, of the upper lock at Gatun be overrun before the upper gate is closed, it would release a head of water of 28 1-3 ft. into the middle lock. Allow, for example, that the safety dam for the summit level could be set in five minutes. The theoretical velocity of water with a head of 28 1-3 ft. is 43 ft. per second, equal to a rate of 30 miles per hour. In the five minutes, or 300 seconds, needed to get the safety dam set, a weight of over 500,000 tons, including the ship, will be precipitated upon the middle lock. If ships are following close after one another it is possible that there may be a difference of 56 2-3 ft. in the levels of the upper and middle lock, and consequently the velocity, momentum and weight of the torrent will be more than doubled. The ship will become a swift, gigantic catapult in the grasp of water. Reversed engines could avail nothing against this avalanche. In a few seconds the ship would strike the third set of gates, release another 85,000 or 100,000 tons, get an accelerated speed. overwhelm the last set, and dive in a maelstrom of hundreds of thousands of tons, rushing in great waves down the 85-ft. stepped slope

Without a safe safety dam nothing else can happen either here or at Lake Sosa than that the ship will be seized by the flood, millions of pounds of steel gates and millions of tons of water will hurdle down through the lower gates, tear everything to pieces, bury the flight-wreckage in a fathomless gorge in the marshes, and sweep its devastating way to the sea.

The deep concrete-founded locks must inevitably be eroded by the torrent flowing through and then around. The huge Gatun dam itself would be in almost inescapable peril, because the locks are an integral part of it. Every vessel in the waiting basin and every building and structure between Gatun and the sea in its path would be swept to utter annihilation.

The damage to the canal and locks could not be repaired for years. To refill the Gatun lake would consume nearly a year of itself. The adoption of the lock flight arrangement, which puts so fearful a premium upon an accident, cannot be characterized as other than a most colossal and disastrous mistake. No money should be voted for construction except as the canal is safeguarded by the exact proviso, "Locks in flight are prohibited at Panama."

With the passing of the lock flights will pass also the monster dams.

What can be done to remedy the situation? The analysis of all safety measures brings one back to the living fact—the lock flight cannot be safeguarded, its perils are inevitable. It must go; in that direction alone lies safety. With one separate single Gatun lock of but 29 ft. lift the efficiency of the safety gate system can be much more than doubled by inserting an intermediate gate midway down the lock. To any vessel less than 600 ft. long there would be on entering the far greater safety of having not merely 80 or 100 but at least 400 ft. of water to overrun after breaking through the doubled gates before reaching the extra gate on the same level. Besides, there is ample room for a safe safety-summit dam and well-founded approach piers.

In the case of a vessel larger than 600 ft. there is still far greater leeway allowed by the single full separate lock proposed, than under the Minority's system.

Considering the event of a ship's crashing through all gates, though it is far less likely under the separate single-lock disposition, still it is possible. But the damage would be confined there largely to the lock gates themselves, because there is the further surety of controlling by the right safety dam system.

But even with the low head, though an accident is far less likely, the eventuality must nevertheless be faced of a gate's being knocked out sometime. It is in the absence of serious consequences therefrom, in addition to the smaller likelihood of the event, that the final superiority of the isolated lock type rests.

A Torrent of Death.—Under the experts' design a torrent would tear down into the canal itself, and the ship's waiting basin, while the water escaping in this separated four-lock canal would be caught, and its shock dissipated and absorbed

not in the channel but in the broad lake below. The low slopes on its borders would permit an immense volume of water to be added without a great rise of level. In addition to this lake absorbing and neutralizing the shock, the row of ample sluices especially designed in the barrage to discharge any excess flood, would further prevent undue rise. The consequences from a breaking loose of the upper level, thus guarded against, would be confined almost entirely to the damaged gate and things afloat.

The Three Lake Project made on this principle of isolated locks and low summit level incorporates not six locks, but four locks. The danger here again is therefore, from this elimination of two locks, reduced one-third. The only efficient solution giving a safe plan for the canal is this low head and isolated lock system.

In November, 1907, another complication is bruited—two kinds of gates!

"The gates are to be in duplicate and of the miter type and the rolling gate similar to that now in use on the Ohio River will be substituted for the duplicate set at the lower end of each summit level lock. In addition, there will be provided an auxiliary pair of gates at the lower east end of each flight for use as coffer dams in case it may be necessary to pump out the locks."

The rolling gates increase the hazards but they take up less room than the mitering type and thus help fit the locks to the abbreviated sites. Incidentally they increase the cost several millions.

In the light of these most conspicuous facts it becomes apparent therefore in review that there are five vital technical objections to the Government's lock flight here:

1.—The tier arrangement is the most hazardous possible.

2.—The rocky ridge of Gatun is too narrow for three locks to be themselves properly bedded on solid strata, with their approaches and the safety dam.

3.—The 1,000-ft. locks in flight cannot be lengthened.

4.—The divided lock system is eliminated, with its inherent advantages of water economy, speed in locking smaller vessels and the availability of an intermediate safety gate at sufficient distance that the momentum of a vessel breaking through an intervening gate would be least likely to carry to it.

5.—The locks shown on the drawings sent to the Senate Committee and announced by the Secretary of War in a magazine contribution as 100 ft. wide set an unwise limit to the width, tonnage and fiighting power of our battleships, some day to be sorely needed one side or the other of this Isthmus. The locks ought to be 115 ft. wide.

These are plain and unanswerable arraignments.

The existence of an adequate solution is the warrant of criticism. Let but one lock be put at Gatun; make the lift not from ocean level, but from a 33.5-ft. lake impounded exactly as is Lake Panama, which the Minority itself has adopted for the other end, but of double its height. Set the upper Lake Gatun at the 62.5-ft. level, instead of at 85 ft. With only one lock on this Gatun site, the technical objections which hold against the three-lock flight are resolved. One Gatun lock lifting between the levels can be located in Gatun hill, so that the lock proper, the safety devices and both upper and lower approaches will be directly in or on the solid rock. No great back fill of concrete will be needed to buttress the walls, no upbuilding of masonry at lavish expense to secure a solid platform. At once the whole foundation question is settled by nature herself in the then sufficient dimensions of Gatun hill.

CHAPTER XIX.

CHAGRES CONTROL.

The gigantic dam and the staircase of locks, too big for its site, together make a high navigable lake. But the water is admitted and the lake created only when the dam is practically completed. The lake is so high that it makes a continuous Isthmian railway all but impracticable. This feature will be considered separately. Through the lake there is a channel of "45 ft. minimum depth." But the ruling depth over lock sills is 40 ft., and in the Panama approach there was provided a depth of but 36 or 37 ft. at low tide. Besides these limitations the Sosa Locks have a lift of but "27½ feet each" or 55 feet for the two in flight, while Lake "Sosa" is 65 feet above low tide.

A large ship is thus hampered, having to await a three hour rise of tide. Delays are momentous emergencies.

The 40 ft. on the lock sill in fresh water is the canal's fixed measure of effective available depth. No ships of deeper draft than the lock sill will pass can negotiate the canal. Owing to the difference in density between fresh and salt water a vessel drawing 38 ft. at sea may draw about 39 ft. 4 ins. in the lake, varying with her block coefficient. Hence, the proposed locks will pass a vessel whose load line limit is 38 ft. at sea with but 9-in. margin. This fact ought also to be reflected in the lock experts' design, but the blue print sent to the Senate Committee indicates that nothing is recognized in this direction.

The flow line of the summit lake is 85 ft. above sea level. It would run far up the tributary valleys of the Gatuncillo and Trinidad. On the latter stream surveys have been extended 60 miles by its tortuous course, perhaps 30-odd miles in a straight line, and in three places the rim of the low range between the Trinidad valley and the slope facing the Atlantic is so low that special measures are compulsory to supplement the Gatun dam. In one saddle the natural height is but 86 ft., one foot above the 85-ft. lake level and this is many miles west of Gatun. The lake would extend up the main Chagres river past Gamboa and the mouths of the Palenque and Rio Chilibre beyond. Here it is to be recorded and observed that the hills of the Isthmus are characteristically steep and the valley bottoms flat and swampy. It follows, therefore, that the flow line of a lake at 85 ft. is, in a

horizontal plane on the average only a little distance beyond or outside of the flow line of a lake at 62.5 ft. A lake at 62.5 reaches beyond and covers as does the lake at 85 the mouths of the Palenque and Chilibre beyond Gamboa. Its flow line does not menace any part of the low Trinidad range. Hence, as a receptacle and regulator of floods the lake at 85 performs no office and has no function which the 62.5 lake does not equally perform. It is no better for canal navigation either. Some stress has been laid on the following table of channel widths:

Bottom Width of Channel.	Lock Canal and Summit Level at Elevation 85. Length.	Per Cent of Route.
1,000 feet	19.08	38.4
800 feet	3.86	7.8
500 feet	12.29	24.7
350 feet	0.00	0.0
300 feet	7.21	14.5
200 feet	4.70	9.4
150 feet	0.00	0.0
Locks and approaches	2.58	5.2
Total	49.72	100.0

But this is distinctly misleading in its practical application because the proper speed in such a lake area should not be over 9.5 or 10 miles per hour for the best steering control in vessels closely following or passing each other. Such a speed requires surface width more than bottom width for the displacement of the water moved in the ship's path. Owing to the flatness of the Chagres-swamp-valley from Mindi to Bas Obispo, in the lakes there is ample width for a ship's bow wave to get away, and for the water to close readily in at the stern and for vessels to pass at the regulated speed. The question is really one of comparative lengths of lake navigation, as the Culebra section is the same for the 85-ft. level as for a summit plane of 62.5.

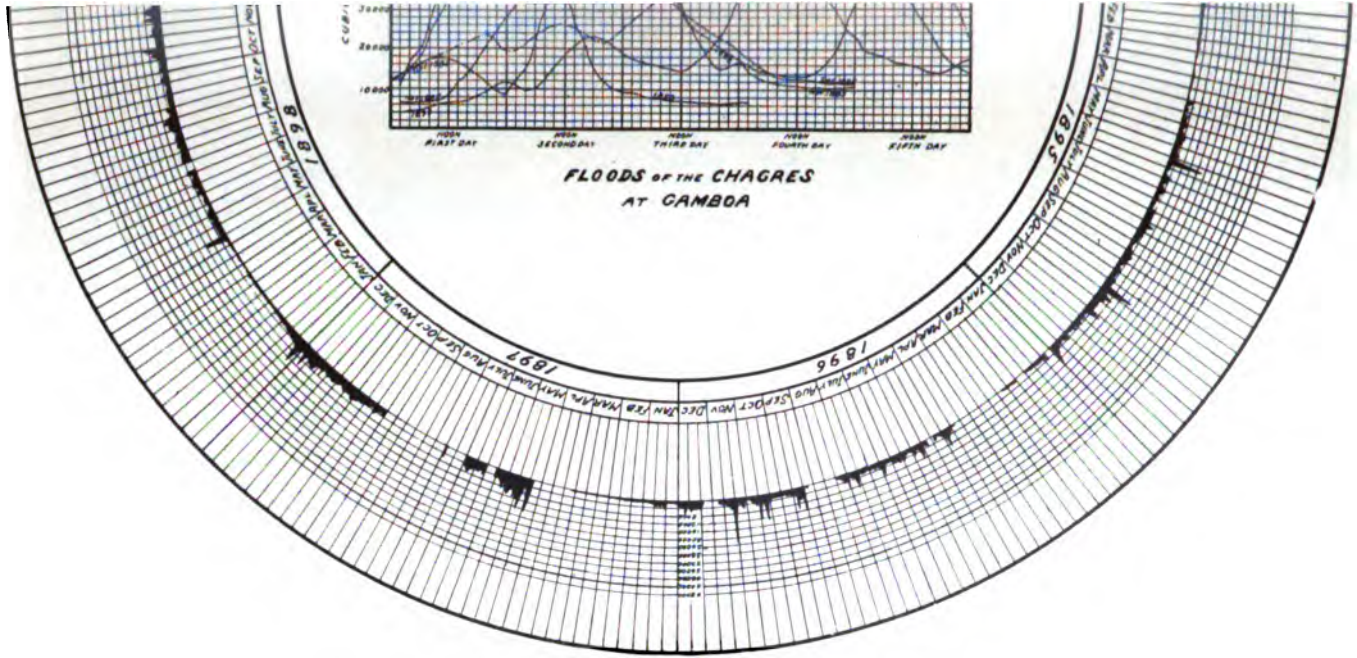
In this comparison the lake navigation afforded by a 4-lock canal is longer than in the 85-ft. canal by the distance between the Mindi lock and the Gatun lock, something over two miles. Further there are two less locks. This means much to conditions of navigation.

A lake created by a dam at Gatun at whatever level has several functions—

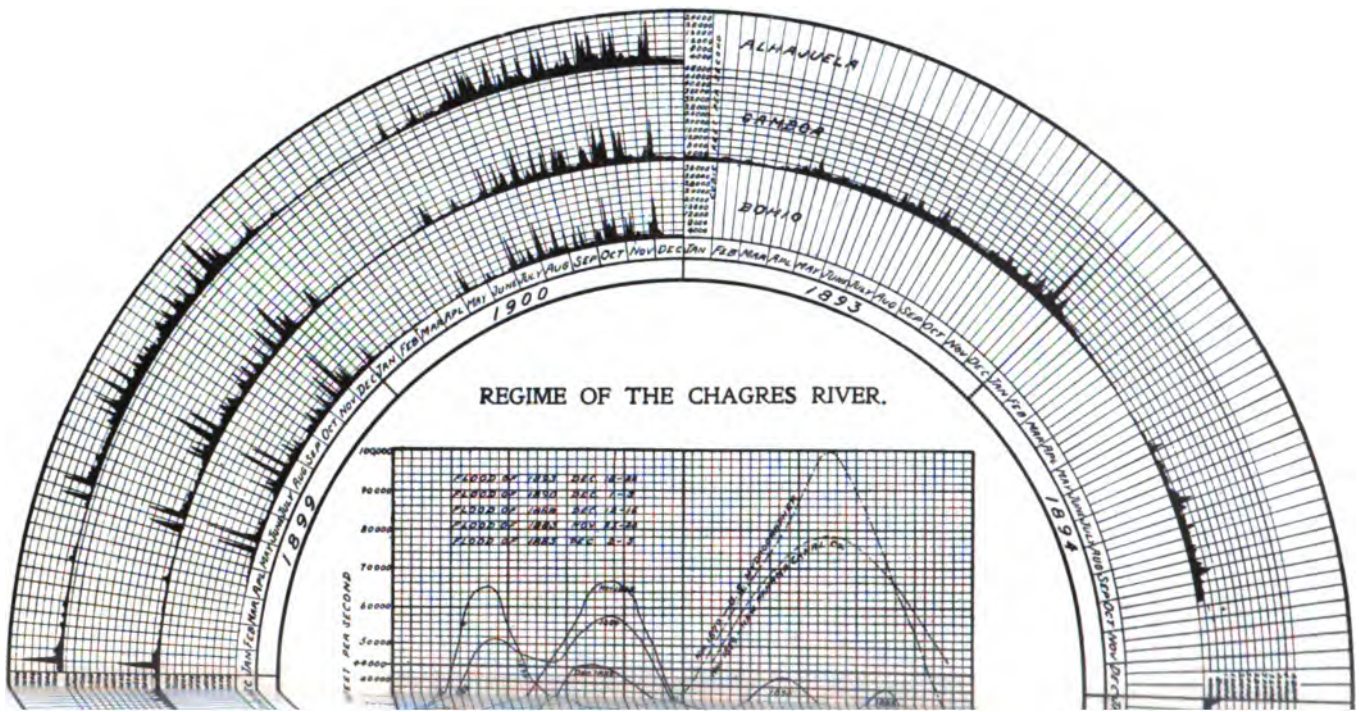
1.—To sanitize the swamp areas.

2.—To assist in regulating the Chagres.

3.—To reduce the excavation between Gatun and Pedro Miguel.



FLOODS OF THE CHAGRES AT GAMBOA. DIAGRAM NO. 1.


ALAJUELA
PANAMA
BOMBO
1900
1899
1893
1894
REGIME OF THE CHAGRES RIVER.
FLOOD OF 1893 DEC. 6-14
FLOOD OF 1890 DEC. 7-8
FLOOD OF 1888 DEC. 4-12
FLOOD OF 1885 NOV. 21-28
FLOOD OF 1885 DEC. 2-7
FEET PER SECOND
100000
90000
80000
70000
60000
50000
40000
30000
1893
1885

4—To create lake navigation for the service of vessels.

5.—To enable floating plant to be employed on excavation and thus minimize unskilled labor.

If the lake be allowed to collect only at the completion of the construction period, it, of course, can perform no sanitizing office during the many years in which the vast labor forces are at work and when sanitation is most demanded. The 85-ft. lake being dependent upon a dam and summit level design, which must indubitably postpone its creation until the great dam is done—ten years hence at least—has absolutely no sanitary value during the construction era.

The regulation of the Chagres by a navigated lake is a desirable and vital function. It resolves best and completely the problem of preventing the silting up of the navigable courses, because the debris of the hills will be deposited far from the navigated tracks at the upper ends of the various valleys and ravines. The lake does more, it acts as a safety reservoir, minimizing currents and absorbing the down-rushing torrents characteristic of the Isthmus.

In connection with this discussion is published a graphic resumé of the hydrology of the Isthmus. The circular diagram shows the record of a decade of wet and dry seasons, as compiled from French observations of rainfall and run-off. It reveals the sequences and suddenness of floods and their short duration. It discloses also their relation to the ordinary regime and to the seasons of drought. It has been demonstrated conclusively that owing to a divergence in results between the American and French observers, who employed different gauging methods, a factor of safety for contingencies should be added to the French totals and averages. The American method gives a smaller flow in the dry season and a larger flow in the wet period, as shown by the following table and by the graphic diagram No. 2.

BOHIO.

Monthly Range, 1900-1901.

MEAN DISCHARGE—CU. FT. PER SECOND.

1900.	Company.	U. S. Comm.	Difference.	Per C't U.S Greater
January	2,120	2,203	83	3.9
February	1,060	1,052	9	- 0.7
March	740	681	59	--7.9
April	706	652	54	—7.6
May	1,620	1,670	50	3.
June	2,860	3,185	325	11.3
July	5,610	5,960	350	6.2
August	5,260	5,880	620	11.7
September	4,770	5,190	420	8.9
October	7,000	8,220	1,220	17.4

1900.	Company.	U. S. Comm.	Difference.	Per C't U.S. Greater.
November	6,600	7,540	940	14.2
December	3,740	4,100	360	9.8
1901.				
January	1,483	1,508	25	1.6
February	989	937	52	—5.2
March	706	654	52	—7.3
April	565	521	44	—7.8
May	2,296	2,400	104	4.5
June	2,790	2,890	100	3.5
Average total 1900 and 1901	2,828	3,069	241	8.3
Average 9 wet months 1900 only	4,398	4,883	485	11.
Average 3 dry months 1900 only	835	795	40	4.7

From this comparison one deduction of special value can be made. This is that there must be allowed in all calculations a margin of safety which for conservative practice must be figured in the least favorable aspect. The French observations were taken over a long period of time. It is wiser to build upon the extended average so obtained and to employ a factor of safety than to count upon a shorter average from the United States Government records.

The Minority submitted an important technical feature at the Gatun lake spillway without providing all that a necessary caution here would demand. This is the second excess which they neglected in their spillway provision.

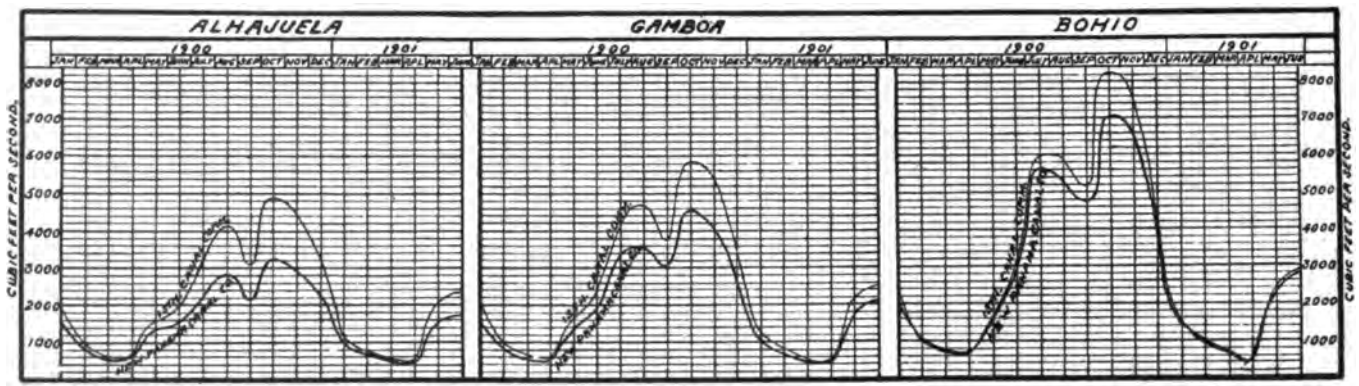
Diagram No. 3 pictorially presents the facts as to the flow of the Chagres at the main observation stations. It particularly emphasizes the value of the watersheds of the Lower Chagres, of the Gatuncillo and Trinidad and Mindi to the problem of all sufficient lockage water for the future demands of commerce.

An elaborate study of the hydrology of the Isthmus was incorporated into the volume, "Panama Canal Systems and Projects," by the writer and published in September, 1905, and the following conclusions were adduced:

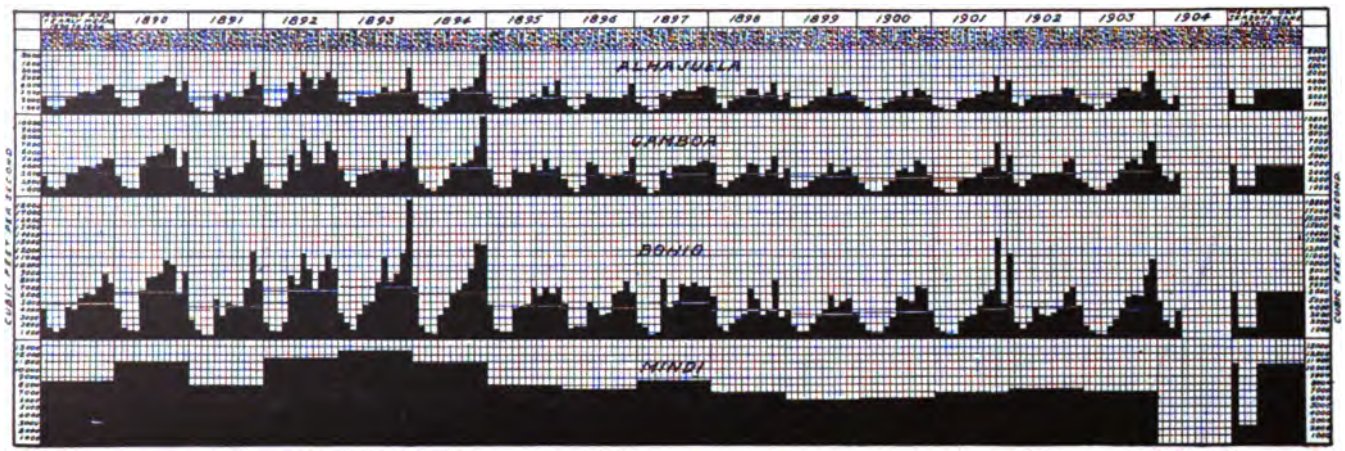
1.—The average yearly wet-and-dry-season flow to be figured on past the ruling points named is:

	Yearly cu. ft. sec.	Wet cu. ft. sec.	Dry cu. ft. sec.
Alhajuela	2,424	2,910	965
Gamboa	3,164	3,827	1,176
Bohio	4,798	5,940	1,371
Mindi-Chagres	8,480	10,510	2,425

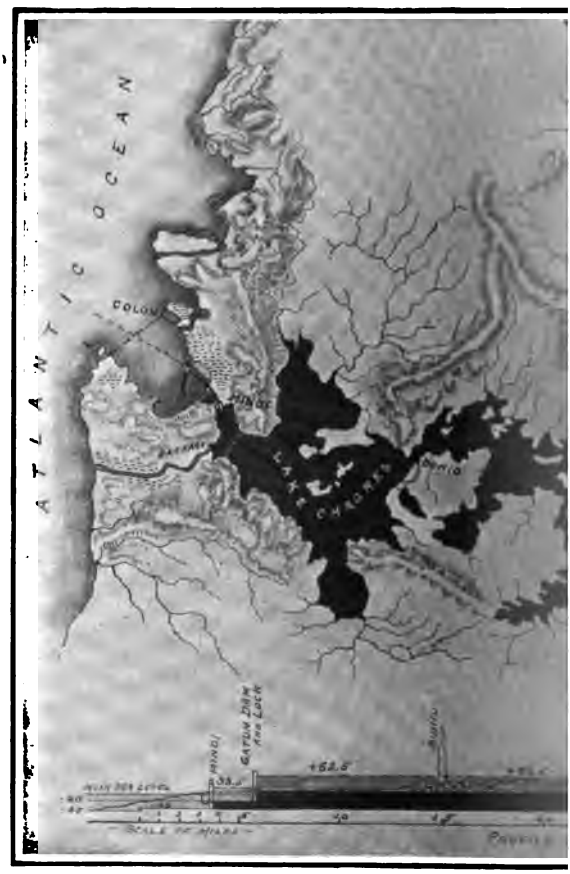
The above table is from French sources and records, and, as shown, must be used with a factor of safety due to the differences in gauging methods.



COMPARATIVE DISCHARGE RECORDS. FRENCH AND AMERICAN. DIAGRAM NO. 2.



MEAN MONTHLY, YEARLY AND SEASONAL DISCHARGE OF CHAGRES RIVER. DIAGRAM NO. 8.



THREE-LAKE PROJEC

BY LINDON W. BATES.

2.—The flood volumes to be allowed for past critical points are:

	Maximum cu. ft. sec.	Average cu. ft. sec.
Gamboa	99,600	83,000
Bohio	140,000	102,140
Gatun (Bohio + 77%)	247,800	.....

3.—Floods of over 44,000 cu. ft. per second occur about every 10 years, and last but 48 hours.

4.—Freshets over 10,000 cu. ft. per second occur 5 times a year on the average, and last 20 hours.

5. The minimum amount of run-off of the whole Isthmus is, for purposes of calculation, 6,000 cu. ft. per second, which, as was seen, is fairly taken as the lowest likely limit of river flow. This volume will practically all pass Gatun.

6.—As to run-off the Chagres valley is normal, and does not differ essentially from another in per cent of run-off to rainfall. Percolation is normal, nor is there any formation which makes the comparative percentage of either surface or underground water at all abnormal.

The 85-ft. project provides for the regulation of this turbulent torrential stream lake regulation only, and precisely such regulation also is afforded by a lake at 62.5—since the flow line of one is so very closely that of the other.

The Lake canal design in addition to its lake provided against Chagres floods at Gamboa, Alhajuela and on the Cano undersluice regulating works like those at Assuan, controlling the vast volume of the Nile. These afforded additional insurance against flood or drought.

Thus the Chagres regulation measures are based upon navigable lake regulation and also what may be termed empty basin control by means of undersluice dams.

The Assuan Dam.—The gifted designer of the Assuan dam, Sir William Wilcocks, C. M. G. and M. I. C. E., thus described his monumental contribution to science:

The Assuan dam is a work of a type which is new in the world. If successful, it will mark an epoch in dam building. There must be sites on the torrential rivers of the arid and semi-arid regions of South Africa, Australia and North America where dams of the type of the one at Assuan will supply a want which has long been recognized. A reservoir dam which will allow the early floods laden with deposits a free and unimpeded passage, and which will afterward captivate the comparatively clear waters of the terminal inundations and early percolations, and store them for subsequent use, ought to put new life into many abandoned projects for perennial irrigation. But the provision of perennial

irrigation is not the only object for which this type of dam may be employed. Provided with its numerous flood openings, it may be looked upon as a weir capable of controlling the mightiest rivers in flood, just as ordinary weirs control them in times of low supply; it may be thus utilized for the regulation of the flood supplies of rivers.

In projecting dams of this type at Cano, Alhajuela and Gamboa, as well as at Mindi and Sosa Barrages, cognizance is taken of this inspiring mile-and-a-quarter-wide demonstration that a continental river may be valved as a waterpipe, and may as perfectly form its allotted task. The Assuan dam, however, had as its function to impound a large volume of clear Nile water, and to let it out gradually during the irrigation season, after allowing the early silt-bearing floods to pass.

Two Methods Compared.—The reversal of this duty was proposed for the three-lake canal in its Panama sluice dams. What is here required is to catch and hold the high floods and by maneuvering the sluices let them run off gradually and harmlessly.

The 85-ft. project is chained to one mode of Chagres control. The new proposal has a primary advantage from having realized the application of the second fundamental method in addition. Its superiority lies in applying both lake regulation and the empty-basin and divided-channel system in combination.

The fundamental method of equalizing the current in a flowing stream has been carefully studied abroad, and, to a lesser extent, in this country. But in general the science depends on the expanding of cross-sections in the right ratio to normalize the currents induced by an increase in volume from affluents.

From Bas Obispo to Pedro Miguel the section of the canal should show a slight expansion with a view to taking scientific care of the watershed of the summit section. An increase of 3% in a standard section at Obispo of 8,000 sq. ft. will rightly accomplish this desired result of having currents normal and regular.

Canvass and scrutinize the records of drought and storms reflected in the tables, the graphic registry of the data gained by a generation of study, the differences between gauging methods; take the lowest minima and the highest maxima and it is not possible to find an hydrologic condition which this, the combined method of control, does not surmount

with abundant and satisfactory ease. It is not possible to find a day, an hour, a moment, when the currents need be undue or when the lockage supply need be inadequate to pass all the tonnage of all the deepwater canals in the whole world.

Silt Problem Met in 62.5-Ft. Lake.—The silt problem, as it occurs in the Upper Chagres, is met through standard and approved means, by incorporating perfect silt traps, whence the deposit is to be removed by independent and self-loading, self-propelling and self-discharging hopper dredges, such as

ALHAJUELA DAM SITE.

GAMBOA AND BAS OBISPO.

are now being used in raising the grade of Galveston, Texas.

It is recognized that a large economy might be effected by leaving out the Alhajuela and Cano dams, and that their sluice gates might not be required for service in a decade or perhaps two. It may even be held that a single large dam at Gamboa of the insubmergible under-sluice type will answer all the flood conditions for their practical regulation and canal navigation, under the severest tests of such deluges as those of 1879 and November, 1906. But the United States should set itself to a perfect work, and to one with every reasonable factor of safety. With the three dams and the 62.5 lake, the nation possesses the instruments by which the

river can be adequately and at all times controlled. It can be governed by any two of them or by the Alhajuela or Gamboa separately without the possibility of harm to the canal or delay to transit. In the contingency of damage from earthquake, from a canal slip or a flood exceeding that of 1879, by possessing these three dams, the control of the Chagres is rendered as certain and precise as human provision can make it. There is in providing three dams no excess of precaution. The goal of solutions and mechanisms should be ideal and the margin of surety should be so great and clear as to lift them high above all intelligent criticism. The combination puts the standard of safety in regulation where no other project can at all rise to it.

In the Nile valley, 500 miles above Cairo, where the rugged hills have closed in to bar the desert, such a dam has been built. Below it stretches to the far sea the Old World granary, the land whose soil has been a treasury. Under this structure holding back its 36,000,000,000 cu. ft. of river, the Nile people are safe and untroubled. Through its gates come measured and controlled the fertilizing waters, and nine millions of Egyptians live under the warrant of the Assuan dam. In the experience of its success no further word is needed in defense of the safety of a project incorporating its construction as an additional feature of flood control, and even this, not with full, but with a normally empty basin above it.

The Gatun Cut-Off.—When a 62.5-ft. lake is made by a low dam of a 29-ft. net head at Gatun it becomes practicable to shorten the canal alignment by a mile and 2,000 ft. (a mile and two-fifths) and to reduce the curvature between Gatun and Bohio. The comparative courses are shown on the drawing herewith. This means an actual shortening of the transit time by an important saving—a time item is worth counting. The three-lake canal incorporated this passage, the sea level and the 85-ft. schemes do not. The profile discloses that this saving of distance, curvature and time may be secured at the price of but a little dredging. What a ship needs especially for lake speed is top width to the navigated section. Then the vessel-made wave has ample room to run away. All the channels across Lakes Timsah and the Great and Little Bitter lakes on the Suez canal, are submerged channels cut through the lake bottoms.

In Lake Timsah there was just such a condition as the Gatun-Bohio section affords. The first navigated course was a roundabout one following the deepest depression of the lake. The Government route in the 85-ft. lake is likewise circuitous. Later a cut-off was made in Lake Timsah and every ship passing directly through, takes it. The very few vessels that stop at Ismailia have naturally to reach it by the old lake channel which opens thither. From a navigation standpoint no navigator would think of taking the long course in this section of the Panama canal, either in the 85 or the 62.5-ft. lake, if the cut-off was opened and buoyed. The failure of experts and Commission to recognize the ship's point of view, in this case also, is in line with all the other defective developments of their project-making at the Isthmus. The Lake Timsah case in the Suez affords a complete parallel, but its cut-off was one comparatively much shorter and hence less advantageous, as well as a very much more expensive matter. Yet its shortening was held of sufficient importance to be incorporated despite the cost.

Another Characteristic Slip.—On page 426 of the Board Report occurs the following:

"Earth Excavation (dredging)—12,960,000 yds. at 25 cts., $3,240,000." This is above the plane of 40 ft.

Now self-evidently this cannot be dredged unless there is water in the lake, 50 ft. of it, or enough to float a dredge over the 40-ft. plane. Hence it follows that this work cannot be begun until the Gatun dam is finished and the 50 ft. of water has accumulated against it. This 12,960,000 cu. yds., which will take a large plant of special dredges two years or more to excavate, must be dug in the "dry," or very seriously delay the completion of the canal. It is another of the characteristic slips of the experts, who entirely failed to take this extra delay into their estimates of the time of completion. Such an amount exceeds that which it will take to fill the site of Galveston or Manhattan Island from Canal street to the Battery 6 ft. deep. Moreover, it is not free from rock and refractory material requiring blasting.

The recent numbers of the "Canal Record" recount in October, 1907, the measures being taken to inaugurate "dry methods" in this section, where they are applicable to a limited extent.

By creating Lakes Chagres and Panama, and later Lake

Gatun, to construction levels, which will not interfere with the railway, provided a small amount of grade raising near the ends is first accomplished, it becomes possible to obviate all dry excavation and employ floating excavators, except at the locks and in the central section between Obispo and Pedro Miguel. The great moment of this provision to minimize unskilled labor has already been strongly impressed.

NEAR OBISPO.

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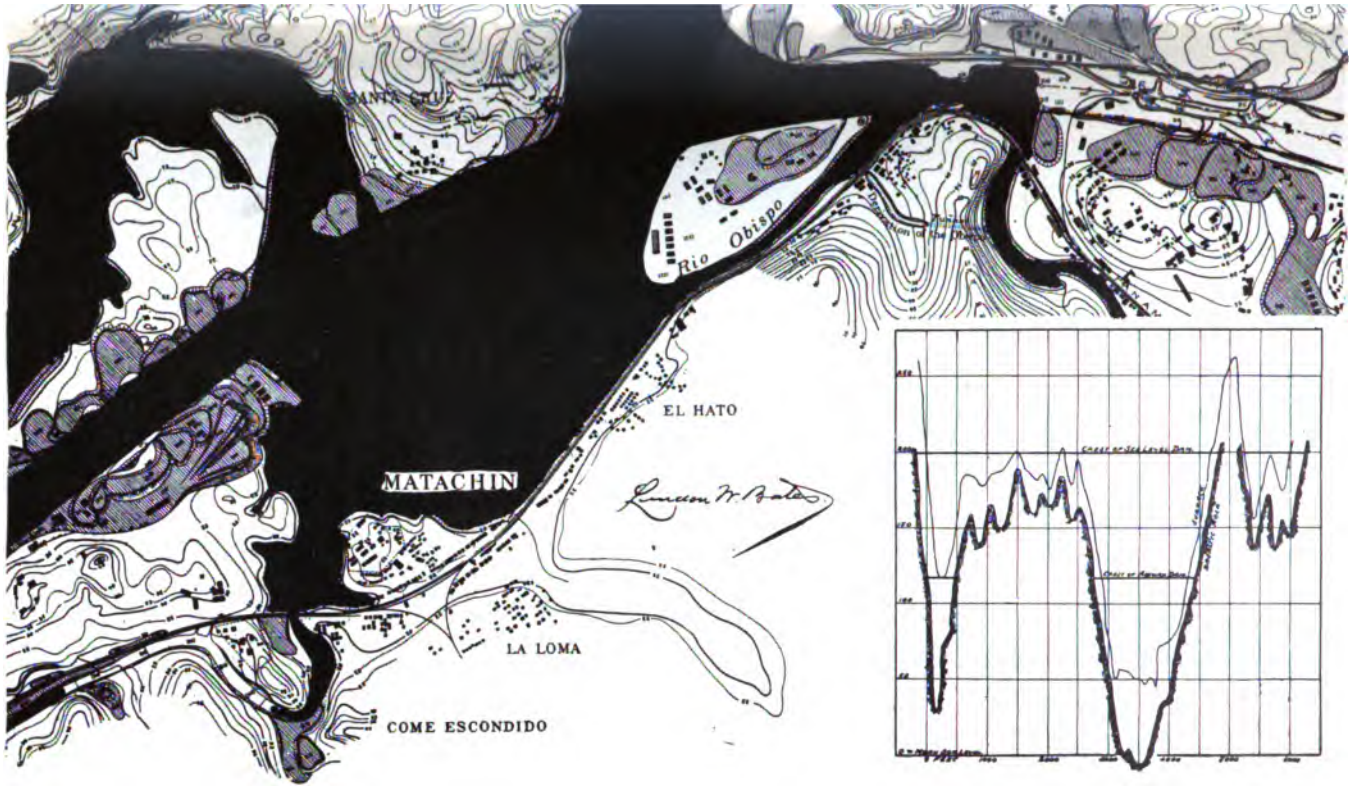


GAMBOA SLUICE DAM AND OBISPO BASIN—PLATE V. THREE LAKE PROJECT.

AMBOA

CHAPTER XX.

The Culebra Division.

The Chagres, running westward, parallel to the backbone of the Isthmus, on its Atlantic side, turns abruptly at Bas Obispo to the north. Here the navigated route meets the Cordillera. Between Bas Obispo and the basin made by setting a lock and dam at Pedro Miguel is the pass of the continental divide, whose lowest point was west of Contractor's Hill. In order to secure a better alignment the French elected to locate their canal bed between Culebra or Gold Hill and Contractor's Hill. The Cerro Culebra is a conspicuous sugar-loaf eminence; being at the place of the deepest cut, its name is broadly attached to the whole central section. At Bas Obispo the height of the river surface above the sea is about 45 ft. at low water. The flow line of an 85-ft. Gatun lake and that of the 62.5-ft. lake are within a short distance of each other, because of the steepness of the Chagres hills.

On the accompanying map the flow line of the 62.5-ft. lake and that of the 85-ft. lake—the 26-meter contour—are both clearly indicated, as well as the profile of the Gamboa gap, dam and the pool for accumulating the silt which may travel down with the river freshets. This would be here provided in both projects.

Can Eliminate Dry Methods.—The spoil dumps left by the French from their sea-level effort are shown in shaded areas; their relation to the channel to be navigated is clear. It is very apparent that when the 62.5-ft. lake is filled to 50-ft. dredges and floating rock-breaking plants have free, safe water access to the north end of the central mass and can attack the whole of the excavations between Bohio and Obispo in dozens of places. They can thus completely there eliminate the dry method, the vast labor forces incident to this, and the severe and crippling handicaps of the nine months' rainy season. They can in addition attack the northern end of the central section, where the rains so adversely affect the steam shovel system to which the government has been exclusively committed in dealing with the central excavation.

It is not the purpose to enter into elaborate details regarding the 8-mile Culebra division. The alignment is

substantially that selected by the French. All American surveys have but demonstrated the soundness of their adoption through these hills, although the centre line of the cut has been shifted slightly to the west at Gold Hill for reasons which will be mentioned later. The whole 8 miles between the Chagres and Pedro Miguel were strewn with French plant of every description, dredges and cranes, excavators, cableways, cars, locomotives, tracks. Barracks are here also and towns like Matachin, Las Cascadas, Emperador (now called Empire and made the canal headquarters), Culebra and Cucaracha or Paraiso.

Here are the American equivalents, steam shovels, cars and locomotives, steam drills, machine and erection shops, repair works, and a most notable array of hotels and hospitals, quarters and buildings for every conceivable use.

Equipment the French Assembled.—The steam shovels and the attendant cars are kept in such a vivid forefront of this Panama activity that one is apt to forget how much vaster an equipment the French assembled for the canal. Their chronicle at a similar stage reads:

"We should note first the seven large American dredges which are to do the excavation at the base of the Chagres valley between Colon and Bohio. These are mechanisms altogether remarkable and of great power. Their monthly output each reaches easily 97,500 cu. yds. Then there are three fairly good dredges which work in Colon Port and two others in the Bay of Panama. They are excellent tools, but of a lesser power. Their monthly output can scarcely exceed 65,000 cu. yds.* The dredges of 180 HP., which are destined to do the digging in the valley of the Chagres and up to Bohio and those of the valley of the Rio Grande up to La Boca, are also equal to getting out without any difficulty 65,000 cu. yds. a month.

The number of dredges actually operating at the Isthmus is 29. This number will be brought to 40 when the orders now in course of execution have been filled.

In the list of water transports, I must specify particularly 10 steam hoppers which take to a distance the spoil of the marine dredges.

Excavators of very different systems have been employed in the Isthmus. Certain contractors praise very much the Osgood steam shovel, which has an effective and great power, and which can dig with its cutters armed with strong teeth not alone stiff earths but rock more or less disintegrated. Unfortunately this apparatus, extremely ingenious as it is, demands very skilled direction, and sometimes repairs very difficult of compassing on the Isthmus, and they have been superseded.

*These very machines rehabilitated after two decades are credited in the official reports of September and October, 1907, with double this French rating! The high record is perhaps explained by the very soft material upon which they are for the time employed.

The greater part of the excavators which have been employed are of the multiple bucket system of Couvreux and Erard.

The number of locomotives for regular service actually engaged at the Isthmus is 169; that of the large cars for earthwork are 4,700; those of the wagonettes De Cauville total the number of 7,000. The tracks for the heavy spoil reach a length of 314 kilometers. The De Cauville tracks are around 180 kilometers. There are a certain number of

OLD FRENCH CARS.

excavating transporteurs at Tavernilla. An important supply of locomotives and of pumps are provided in the stores of the company, to be employed when the depths of the cuttings demand them.

Among the apparatus for loading and unloading we should first mention the two floating cranes of 40 and of 25 tons each which are located, the first at Colon and second at La Boca, for discharging ships. There are 58 light steam cranes. These are entirely insufficient, because of the difficulty which was pointed out of loading the large cars by hand. The company is arranging to increase very materially this part of its equipment. The plant of the workshops per-

mit them to do all the erection and all the important repairs. The foundry below Matachin can handle pieces of a weight of 3,000 kilograms.

There are also in the divers stores of the company provisionings of all sorts, in coal, coke, materials of construction and in repair parts. All kinds of supplies are there, destined, for the most part, to the maintenance and repair of the plant. These supplies are in general judiciously selected. There is to be noted, however, in the stores at Colon a considerable quantity of lime and of cement; 2,200 tons of lime and 2,600 tons of cement, which are already of an ancient date and which do not appear en rapport with actual needs. These materials were provided in view of original works projected at the Colon port which have been abandoned since. The warehouses are well kept up and their suitability seems to be good."

From this recount of the plant, which was everywhere in operation, and the 1,350,000 cu. yds. a month of excavation which the French succeeded in getting out, one can picture the activity which once prevailed on this narrow land width of the Isthmus. The greatest concentration of effort was naturally in the Culebra section, because at that time a sea-level canal was proposed, but the programme of excavation was well carried out simultaneously all along the line. In the Culebra the Americans before 1907 massed almost their whole attack, and here their whole system and achievement may therefore be judged.

A skilled engineer and superintendent from a special mission at the Isthmus supplied the following observations:

"In the first week of February, 1907, there were 63 steam shovels on the Isthmus, weighing, some 45, some 70 and some 95 tons. An attempt to work only about 47 of the 63 shovels was being made. The others were in the yards at Empire or Culebra, or were in the shops being repaired. The distribution of these shovels was about as follows:

From Pedro Miguel to the south side of Culebra cut	7
At Culebra	14
At Empire	16
At Las Cascadas	3
At Obispo	5
At Gatun	2
	47

In the present dry season these shovels were not exceeding an average of 350 yds. per shovel per day. In the wet season they will do not nearly so well, unless circumstances are greatly changed.

The immediate cause of the present low output per shovel, compared with results in the States in this dry sea-

son at Panama, is lack of cars and an apparent lack of system in train dispatching. It is quite a usual sight to see trains standing from 20 minutes to a half hour, waiting for signals.

Looking further for the insignificant output of machines that should be in the dry season, at least, very efficient, it is seen that the dumps are entirely inadequate and badly managed.

January was the red letter month on the Isthmus. All previous American outputs there were distanced. The work was better organized than ever before and everybody, except the men who actually manned and superintended these shovels and knew what they ought to do, was enthusiastic.

The supervisor of shovels at the main section stated that he had not half as many cars as he needed; that the shovels were frequently all of them idle, and that it was a common thing for them to stand hours at a time on this account. He was asked whether he laid the crews of the idle shovels off. No, he did not. They remained on the shovels or were kept busy somehow elsewhere. He could not lay them off. Shovel engineers are paid $210 gold and cranesmen $125 per month, nearly double the ordinary rate in the States. I saw one 95-ton shovel with the fire pulled, but the crew still on it. The engineer said he had been laid up a week and expected it would be another week before he could do any work.

Another engineer in Culebra cut told me that he had been on the Isthmus eight months and he had not put in an average of two hours real work a day. One engineer has a record of 25,000 yds., the best monthly output of any shovel on the Isthmus to date. (A 95-ton shovel working against a face 15 ft. high in clay, that had been loosened by powder.)

A supervisor of the —— —— shovels told me that 240 cu. yds. a day, or 6,000 per month, was a fair average for the shovels on the Isthmus.

The record output for a day's digging of forty machines, he says, is 21,000 yds. He pointed to a shovel on the side of the great cut and said that he had seen that shovel stand one entire week, with a crew on it, waiting for a train. The transportation department is distinct from the operation of steam shovels.

One shovel on the Pedro Miguel section has been nine and a half months in a cut 2,200 ft. long, averaging 8 ft. deep and 30 ft. wide on the bottom. It handled 27,550 cu. yds. in all this time, an average of 2,900 yds. per month. The delay here was due largely to the fact that the rains make it very difficult for these machines to work in the soft clays. Many were unable to work during the rainy season in the upper soft clays, which become fluid mud.

A supervisor at another place pointed out one shovel which he had been able to start January 20. During the entire rainy season it had been idle. The rains begin again in April.

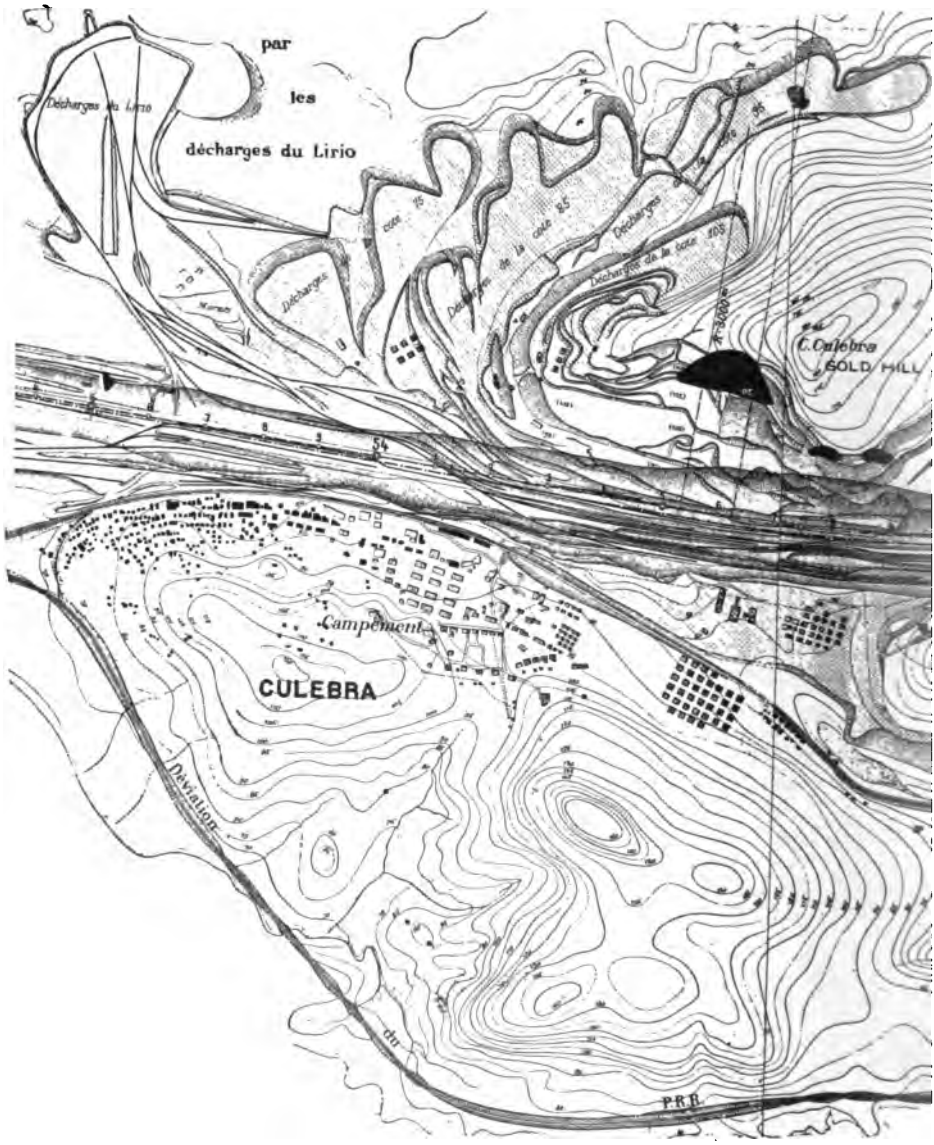
On January 30 I went through Culebra cut and counted 5 out of 14 shovels that were idle during the entire time that I was there. The other shovels were working intermittently. On January 31 I counted 6 entirely idle. I talked with many of the engineers in Culebra and Emperador. They were about a unit in declaring that two or three trains a day of 10 to 15 cars was an average output. The cars used are Western side dumps of 10 to 12 yds. capacity, flats of about 20 yds. capacity, and the old French side dumps. It takes one of the 95-ton shovels about 40 minutes to load the average train.

All along the line wherever these machines are working the conditions are the same. At Bas Obispo I saw two operating attended by one train each of three cars (Western side dumps of 12 yds. capacity).

The supervisor close to headquarters was the only one on the Isthmus with whom I talked who seemed to think that the Government was doing as well as could be expected and as well as any contractor would do."

Such was the actual condition ten months ago. The interval has witnessed a complete change of dynasty and a gratifying increase in output. An official report dated October 16, 1907 states that in September, 1907, an average of 38½ steam shovels handled 749,529 cu. yds., 70 per cent. rock and 30 per cent. earth, against 21 1/3 shovels in September, 1906, which excavated 291,452 cu. yds., 64 per cent. rock and 36 per cent. earth. The rainfall of this month in 1907 was nearly double that of the previous year. The increase is to be attributed to more cars and better train service. The largest part of the spoil still goes to nearby dumps.

The close of the dry season, April, 1907, recorded the best Culebra output so far attained—879,527 cu. yds. October, despite rain, has fallen but little short. The total output of this month is stated to have been 1,868,729 cu. yds. But of this 42% was the easiest possible dredging of light sand in front of Colon and seaward of La Boca, where the new channel is exposed to endless resilting and the gain is not permanent. The removal of this 783,404 cu. yds. cost possibly $75,000 while the remainder, 1,085,325 cu. yds.—58%—is chargeable with the monthly outlay of approximately $2,750,000 or about $2.50 per cubic yard. This is *five times* the average estimate of dry excavation allowed by the experts and *three times* their allowance for Culebra work. Practically the dry work cost *twenty-five times* the dredging. It is the steam shovel system which requires the vast labor forces, the Railroad plant and the building, sanitary and miscellaneous expense.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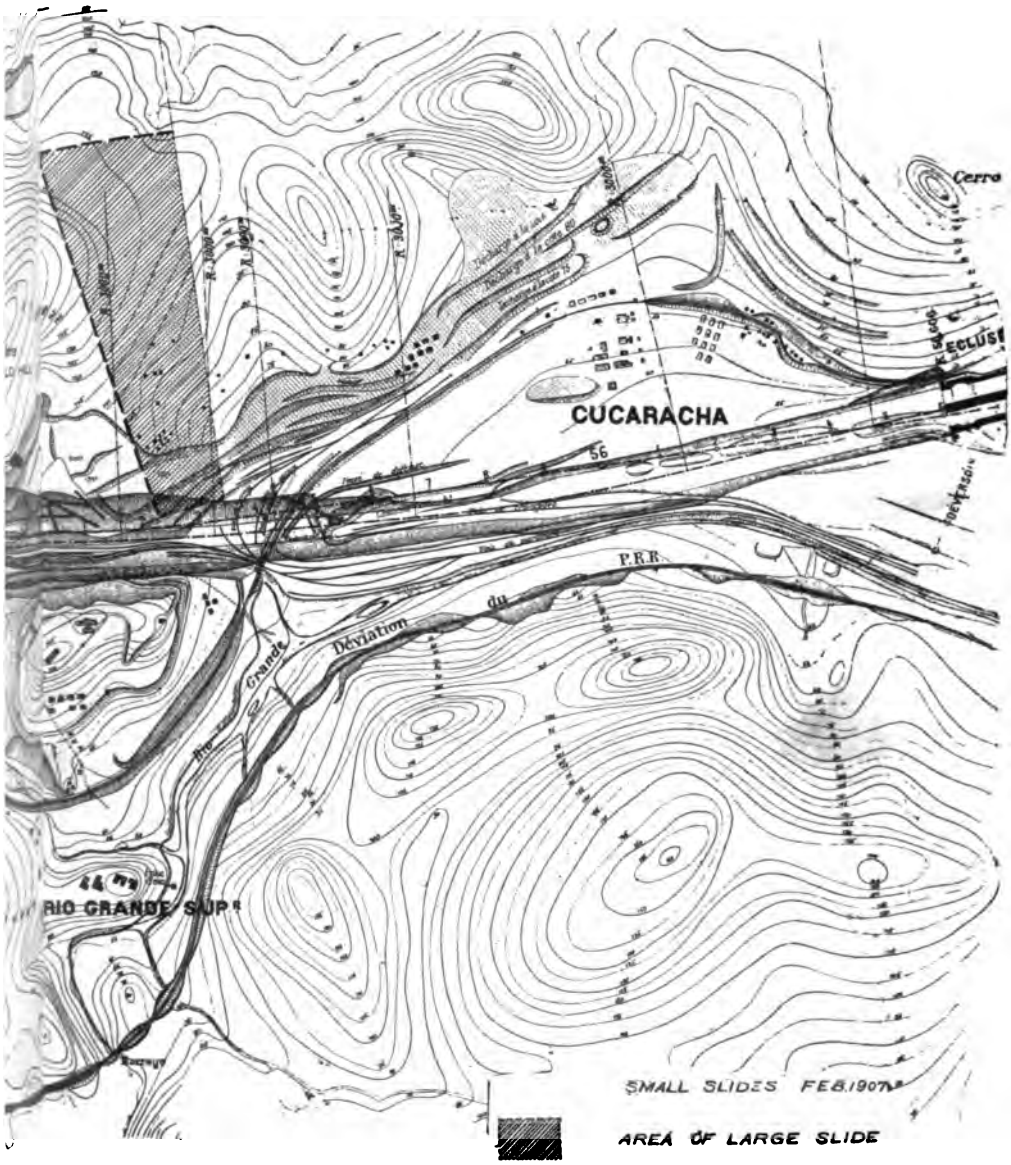


CEBRA CUTTING.

CHAPTER XXI.

Culebra Cut.

The original summit of the Culebra cut measured 333 ft. above sea on the centre line, 300 ft. at the lowest place to one side. The French dug it down to 157 ft. A report early in 1907 from one especially fitted to know reads:

"There has been no deepening of the cut below the bottom grade left by the French. The President was misled into thinking that the Culebra had been lowered 65 ft. by the American forces, when, as a matter of fact, only two small narrow ridges carrying some cross-over tracks have been taken out. The ex-chairman in his farewell speech reiterated this deluding assertion. The executive was misled in many other ways, according to current accounts."

A member of the Advisory Board and other Boards, writes to the "Harvard Engineering Journal," June, 1907:

"The question is often asked, when will the canal be completed? The works near Gatun and the cut through the continental divide fix the probable limit. In estimating the duration of the latter it is not uncommon to divide the total volume by the assumed annual output of the whole number of steam shovels provided. This is far from correct, for the real cause of delay is concentrated in about a mile of deepest cutting and the number of shovels possible to employ becomes less and less as the depth increases. Meantime, the greater part of the eight miles of cut will have been completed and much of the plant will have been standing idle. The official estimate of time of completion taking all circumstances into account was nine years *and we are now just beginning.*"

All the work done has been confined to widening the section and removing land slides.

The sliding in the Culebra is thus far confined to the upper red and yellow clays, and is most evident in the high slopes of Gold Hill, though in a smaller way it is taking place also at other points along the cut. This phase of the Culebra problem is receiving considerable attention. The centre line of the cut has been shifted to the west at Gold Hill, so that the sliding clays may be disturbed to the least degree. This throws the line into Contractor's Hill, said to be composed of the hardest material in the divide. Underneath gray-black hardened volcanic mud, water-bearing sands and gravel are visible in some openings which have been made.

Slopes Continually Sliding in.—The south slope of Gold Hill is composed of red clay, and the slopes left by the

French are continually sliding in, just as they did in former times. A slide from the north side of this hill took place not long ago, carrying away the tracks and trestles on the terraces and landing in the cut below. From the face of Gold Hill smaller masses have dislodged recently.

On the south side of the hill, there is now a persistent movement of the slope toward the cut which extends back at least half a mile. The natural incline of this mass is

CULEBRA CUT.

about 6 to 1 for several hundred feet back to the slope line; beyond that the incline rises more rapidly. Great faults in the surface mark this movement all the way back. A steam shovel worked during the daylight hours at the foot of the constantly moving slide in February, 1907, and was withdrawn every evening to avoid being overwhelmed during the night. The "Canal Record" of October 23, 1907, has this "Note of Progress":

"THE CUCARACHA SLIDE."

"During the past week the work of removing the material cast in Culebra Cut by the Cucaracha Slide has continued with undiminished energy. Electric arc lights have been erected at the slide and the work has been carried forward day and night with three steam shovels. The effect of this has been to gain slowly but gradually on the slide and it is hoped that within ten days or two weeks the movement of material trains through

the Cut will be resumed on the old schedule. This gain has been achieved in spite of the fact that during the last twenty days the rainfall has been the heaviest of the year." The slide overwhelmed two shovels October 4 and the total mass in motion is stated October 9 to be half a million cubic yards. "During the first two weeks the slide moved steadily toward the cut at the rate of 14 feet per day."

This glacier-like movement is due to springs and to the saturation of the upper clays during the rainy season, at which time they become almost fluid mud, which slips on the smooth, hardened gray clays beneath.

A thorough system of ditching and probably some drainage tunneling extended for half a mile or more back of the cut would help save these slopes from saturation and sliding, but it is very evident that both sides of the cutting through this material will have to be considerably flatter than is called for by the present plans, or other measures will have to be taken than those now in evidence of contemplation, both as to the slopes and the means to prevent the blocking of the navigated channel when open. A sight of this sliding country is an eye-opener to any one smitten of the sea-level illusion.

Shovels are working on different terraces of the cut. In the rainy season it is very difficult to work on the upper soft clays, and this part of the excavation should be done in the dry season. About half of the shovels are still working in the lower hard formation.

"Powder is being used throughout the section both in the hard gray volcanic mud and in the soft upper clays. The explanation given for shooting the clays is that they stand straight, and by this shaking up the "slopes move to the shovel."

Disposition of Spoil.—Commissions, advisory experts and chiefs have come and gone in our three years, and the procession continues.

When one scans the Board's report, that of Majority and Minority alike, for light and a deliverance on this pregnant subject of the Culebra distribution, he is amazed. Nowhere can anyone discover what they are going to do with Culebra or other excavations. One sees, however, much of steam shovels and a reference to "transport being the principal Isthmian problem." (Page 60, Report.)

"The Board recognizes that the removal of the material in the summit cut is in reality a problem of transportation.

It is a comparatively simple matter to excavate the material within a much shorter time than that allowed for the work,

A CULEBRA TERRACE.

even on the supposition that all of it except the clay near the surface must be shattered by preliminary blasting. The whole difficulty attending this part of the construction of

the canal is attached to the removal of the material from the shovels or other excavators to the spoil banks. This problem of transportation is in reality the substance of the problem of building the trans-isthmian canal, and in treating this part of the project the Board realizes and has considered the large amount of railroad track and the extensive transportation organization required for the disposition of the waste material. It is probable, as has been estimated, that not less than three miles of standard track will be required for each shovel employed, making a total of 300 miles of trackage for 100 shovels.

It is to be assumed that 100 shovels are available for continuous work, there being a sufficient surplus above that number undergoing repairs, whenever necessary to maintain the working complement, it can be demonstrated that as much as 20,000,000 cu. yds. of material classed as rock may be annually removed from the summit cut.

The time required to remove this great mass of material, by far the greater part being soft and hard rock, will depend greatly upon the efficiency of the method of operation and the organization of force and plant, all of which must be ultimately the result of most careful consideration of all the factors, including those of climate and character of labor available."

Where does it go? Not to Panama breakwaters to stop the endless dredging of unprotected approaches or to reclamation of the Panama tide lands, making a useful property, of many times in extent the area occupied by the present city itself. The Rio Grande valley is pre-empted for the care of its watershed, whence 8,000 cu. ft. per second must some time run off.

A Riddle and a Mystery.—What a travesty this of pretense at solving the Isthmus problems while leaving spoil distribution, so far as they enlighten, a riddle and a mystery.

It was stated December 17, 1906, that the Culebra spoil is to go to the dams—the dams! There remained to be excavated under the 85-ft. plan 53,800,000 cu. yds. from the Culebra section, to say nothing of over 14 million cu. yds. right adjacent. Nowhere in the International or Commission reports is it told what they propose to do with this spoil. The late chief engineer testified that it would be a good thing to mix it with the mud batter that is to go into the Gatun dam, but he tells not how much. He would also put some "below Bohio," in his testimony before Senate Committee. It is understood that he proposed to haul half each way somewhere from the centre of the great cut. We must assume, in tracing what is intended, that about 27,000,-

GRANDE TRANCHÉE DE CULEBRA
CALM

000 cu. yards are to be carried toward the Pacific. Apparently (p. 245) there go to—

	Cu. Yds.
Back filling and embankment, Pedro Miguel	390,000
Dam, Pedro Miguel	1,100,000

This, however, is nearly offset by the excavation from mile 39.60 to 41.47.

The Minority seem likewise to have:

	Cu. Yds.
Mile 41.67 to 45.08	220,000
Excess from Sosa lock	480,000
Outside the lock	5,330,000
Total	6,030,000

The Ancon-Sosa, Ancon-Corozal or Sosa-Corozal and La Boca dams require some 11,697,000 cu. yds. It is unlikely that over 1,280,000 cu. yds. from the above 6,030,000 cu. yds. would go into the dams; around 17,000,000 cu. yds. must go somewhere outside of "Lake Sosa." Possibly it is intended that part may go into the area east of the Sosa-Corozal dam and be lifted high in the air, providing the drainage of the Juan Diaz and Puente creeks is properly cared for—another thing which the experts overlooked. A considerable area is drained by these creeks, but no provision was apparently made for their run-off. There remain millions and millions and again millions of cubic yards still to go—where? Far to sea by barges? This would be a grave waste of opportunity to make breakwaters to the islands, to stop littoral drift and resilting or to make reclamations, serving useful and valuable commercial or military purposes.

Like the Line Around Lake Baikal.—We have heard much of the French transporting Culebra spoil up hill, but it is not recalled that they were ever guilty of proposing to carry 10,000,000 cu. yds. down hill and then to hoist it into huge 80-ft. dams overhanging Panama or to haul 20,000,000 cu. yds. to Gatun and lift them then growingly to 135 ft. Further we have the new railway embankments of the experts across the arms of Gatun lake. The profile of this extravagant proposal looks much like the line around the shores of Lake Baikal in Siberia—a succession of vast fills, deep cuts, tunnels and bridges and ram's-horn curves. It will take plenty of dirt and gold to grade this railway around and across Lake Gatun at 85 ft.

Where is the spoil going? An engineer's report in February, 1907, summarizes:

Dumps— "For the Pedro Miguel, Culebra and Emperador sections there are five short, low dumps on the east side of the Panama Railroad tracks between Corozal and Pedro

Miguel. In addition to this there is the La Boca track extension, which has so far absorbed a large portion of the spoil of these sections.

Part of the material from Emperador goes with that from Las Cascadas and Obispo to the short dumps, four in number, scattered between Las Cascadas and Mamei, or to the larger dump which is being extended east of the Panama Railroad into the swamps at Tavernillo. The Bas Obispo cut has two small dumps on the east side of the excavation, not over 1,000 ft. long.

The spoil from the Gatun lock excavation is being put a

STEAM SHOVEL IN CULEBRA CUT.

little distance east of the lock site on a very short but fairly high bank, which, like all the others, has one blind siding on it and accommodates but one train.

The dumps are all too short, all too low, and all so arranged that but one train at a time can be accommodated on them. Thus the minimum of service is obtained from the trains operating, because of the long delays to which these are subject whenever they endeavor to get on to the spoil areas.

Tracks on these are always in bad condition, and are often impassable, especially in the rainy season, because it is necessary to be constantly shifting them on account of the lowness of the dumps. Gangs of 50 to 100 men are contin-

uously employed for track moving, where a gang of ten on a properly selected and developed dump would take care of the disposal of five times the material.

Owing also to their shortness, these places accommodate but one small train, and make it necessary for the cars to go in and out at the same point and thus hold all other trains waiting.

Spoil tracks are installed at Corozal, apparently for the new substitute dam across the swamp to Sosa Hill, but the borings for this dam are just begun. One good dump on the tide flats west and south of Panama City, properly arranged so that trains might enter or leave without interference with each other, and with unloading devices of a well studied character, would easily dispose of twice the material that is spoiled now on the fourteen or fifteen dumps and at one-fourth the dumping cost."

It is sufficiently clear that in order to get a record under stress of pressure, the record sought to justify the expectations of the country, no spoil was going to the dams. They are too far away. None was going to the railway embankments around the lake-to-be; none was going to the breakwaters or valuable reclamations; none to raise Colon. Where? Just to the nearest places, without reference to anything but disposing of the output. The putting of tens of millions of cubic yards of spoil into dams and embankments is a very different proposition from the procedure of this record-striving exhibition. The dump at Tavernillo is greatly to be deprecated, from the standpoint of a lake lower than 85 ft., since it may unnecessarily limit the navigated widths. The "Canal Record," September 18, 1907, has this official item:

DUMP-GROUND RECORDS.

The following is a statement of the amount of material handled from the Culebra Cut at the different dump grounds during the month of July:

La Boca	90,510 cu. yds., or	12 %
Sosa-Corozal dam	42,714 cu. yds., or	5½%
Corozal	62,389 cu. yds., or	8 %
Pedro Miguel	32,240 cu. yds., or	4½%
At inside dumps from Paraiso to Bas Obispo	210,698 cu. yds., or	28 %
Gorgona	15,673 cu. yds., or	2 %
Juan Grande	48,106 cu. yds., or	6½%
Mamei	33,471 cu. yds., or	4½%
Tabernilla	218,363 cu. yds., or	29 %

This table shows that there is still being dumped on the inside or those dumps close to the Division, the largest per cent. of the excavated material, the dumps north of Bas Obispo taking only 42 per cent of the total output."

All these waste dumps in the upper Chagres and upper Rio Grande valleys are food for erosion and channel obstruction and a hindrance to the lowering of levels.

Chief Engineer Stevens' Report on Excavation in Culebra Cut.—Washington, Feb. 16.—Secretary Taft received the following dispatch to-day from Chief Engineer Stevens of the Isthmian Canal Commission at Culebra:

"February, with twenty-three working days, will probably show 600,000 yds. of excavation in Culebra cut, and March will show 800,000 cu. yds. excavation."

It was very difficult then to reconcile these claims and prophecies with skilled observations on the ground, at the cuts, on the terraces, at the shovels, on the distribution tracks, at the feeble dumps, with the idle waiting of shovels and cars and locomotives at both ends and with three car trains. Time, unstinted money and straightforward devotion have wrought since a measure of retrieval. Godspeed! What is doing now is but the froth of the glass, that one blows away, compared with the realities of the coming task in deepening the Culebra, in the morasses, in the lock pits and spillway, in the vast dams and railway banks, in the concretes, in labor and sanitary destinies of this 85-ft. scheme. Godspeed!

It is for us a gallant army—white or black, American or Spanish, who land at Panama, with all the vigor of mountain blood and the sinews of hill-born strength. Why must the thing be done the hardest way, the longest way, the deadliest way, the costliest way?

Operations in Culebra Cut.—A table is subjoined, giving the dry excavation since the United States took hold of the work in Culebra. (Congressional Record, p. 4215.)

Memo. of excavation operations in Culebra cut:

1904:	Cu. Yds.	Total Cu. Yds.
July	31,599	
August	35,056	
September	25,220	
October	19,695	
November	28,860	
December	42,935—	183,365
1905:		
January	70,650	
February	75,200	
March	132,840	
April	126,749	
May	75,935	
June	76,905	
July	78,570	
August	49,210	
September	*50,000	
October	52,940	
November	60,540	
December	70,630—	930,169

	Cu. Yds.	Cu. Yds. Total
1906:		
January	120,990	
February	168,410	
March	239,178	
April	213,177	
May	194,645	
June	207,760	
July	157,093	
August	244,844	
September	292,000	
October	325,835	
November	221,642	
December	278,197	—2,668,771
1907:		
January	566,750	
February	*650,000	—1,216,750
Total to March 1, 1907		4,984,055

*Estimated.

In addition to this the following letter is interesting, because it has been lately made the basis of some comparisons by the Panama Directorate invidious to the French records:

Isthmian Canal Commission, Department of Construction and Engineering, Culebra, February 15, 1907. Hon. Wm. H. Taft, Secretary of War, Washington: Dear Sir.—I have the honor to quote from the report of work done by the construction and engineering department of the Panama Canal for January, 1907, as the matter will probably be of interest to you:

During the month of January there was removed from the canal prism 566,750 cu. yds. at a cost of 57.22 cts. per cu. yd. This yardage shows an increase over December of 288,553 cu. yds., and also shows a decrease in cost of 29.80 cts. per cu. yd.

The yardage gotten out during January is the greatest taken out of the canal prism in any one month since the Americans have had control, and exceeds by 240,915 cu. yds. the best previous month.

In looking over the only records available here, the Bulletin du Canal Interoceanique, the official publication of the first French Canal Company, published in Paris, it has been found that in any of their most active years—when their output for the year 1886 was 15,338,916 cu. yds.—there was never more than 20 to 21% of the total yardage of the entire canal taken out in that section of the canal now called the "Culebra division." This publication shows that during May, 1886, of the total output for the canal of 1,412,640 cu. yds., only 209,280 cu. yds. was removed from the section now covered

During October, 1886, out of a total of 1,230,828 cu. yds., only 264,216 cu. yds. were removed from this same district.

December, 1886, had a total output of 1,083,024 cu. yds., and only 209,280 cu. yds. was removed from that section now covered by the Culebra division.

The above figures show that during the month of Jan-

uary, 1907, from the records that are available, the output of the Culebra division probably doubles that of anything taken out in a month by the first French Company from the same section of the canal. Yours truly,

John F. Stevens, Chief Engineer.

Comparisons Are Misleading.—These comparisons are unintentionally misleading. The French force was not massed in the 8-mile Culebra section between Obispo and Pedro Miguel.

Work in the dry extended from Bohio to Miraflores in 1886 and besides dry excavation was progressing on the Jacob contract for the Diversion near Mindi.

The official report of the eminent engineer, M. Rousseau, especially appointed by the Government of France, reads as follows:

	Cu. Meters.
"January, 1886, had for output	1,067,823
February, 1886	1,018,000
March, 1886	1,097,000

Not counting the dredging operations, which employ but a small personnel, and the machine shops, we find that the number of workmen on the earthwork in the dry amounted in the month of January last to around 9,500 and gave an output of 490,000 cubic meters approximately."

This was an equivalent of 637,000 cu. yards, in January, 1886, taken in the dry, mostly between Bohio and Pedro Miguel. The period from 1883 to the end of 1885 corresponds to ours from July, 1904, to July of 1907.

From as minute an investigation as possible, M. Guillemet, Depute, in an official report to the French Government, deduced the following striking conclusions:

"The results attained by the small contractors (petits entrepreneurs) were the best, and their period was not characterized by the grasping and pillaging of the period of the great contractors, which succeeded.

The small contractors extracted altogether from the canal diversions and accessory works 13,623,364 cubic meters (17,710,373 cu. yds.) at a cost to the company of 73,860,621 francs"—(or 83 4-10 cts. per cu. yd.) This was in the era from 1883 to 1885.

In order to catch up with this progress of the French, there must be taken out in the dry during each of the coming four months, April-July, 3,000,000 cu. yds.! Our outlay to March, 1907, has been thus far during the time of this excavation of 5,000,000 cu. yds. (4% of the earth and rock to be excavated on the canal and lifted into high dams) roundly $44,000,000. When on dry work our output attains that of the French period of small contractors the outlay will reach over $80,000,000.

From the "Canal Record" of October 9, 1907, the following "Record of Excavation" since American occupation is taken. It differs somewhat from the report to Congress:

AMERICAN EXCAVATION TO OCTOBER 1, 1907.

C. Y. FROM CANAL PRISM.

Year.	Culebra.	Gatun Locks etc.	La Boca Locks, etc.	Colon.	Panama Bay
1904	243,472	.....	.....	.....	.....
1905	914,254	.....	.....	.....	.....
1906	2,702,991	26,628	.....	.....	.....
Nine Mos.				29,568(S)	
1907	6,526,334	724,667	17,568	729,591(D)	485,599
Totals	10,387,051	751,295	17,568	759,159	485,599

C. Y. FROM OUTSIDE PRISM.

1905	.....	.....	.....	399,820	485,153
1906	.....	.....	.....	1,027,645	1,191,233
1907	.....	45,325	28,830	643 828	584,099
Totals		45,325	28,830	2,071,293	2,260,485

Grand total by dredges to Oct. 1, 1907.....5,546,968
Grand total by steam shovels to Oct. 1, 1907.....11,259,637
Grand total by both to Oct. 1, 1907.....16,806,605
Grand total inside prism to Oct. 1, 1907.....12,400,672
Grand total outside prism to Oct. 1, 1907.....4,405,933

It is all officially set forth now as "place" measurement albeit the Chief Engineer's report in 1906 shows that the dredging at Colon and Panama Bay was more or less futile from resilting and that the tally was reckoned in the "clapets" or by "scow measure" which is usually 20% more than excavation measurement.

To November 1, 1907, the latest information summarizes:

Division.	C. Y. From Canal Prism.	C. Y. Outside Canal Prism.
Chagres.....	47,173	2,200
Culebra.....	11,221,730	.....
Gatun Locks, etc.....	928,308	45,326
La Boca Locks, etc.....	24,676	36,205
	70,646 (S)	
Colon and Mindi.....	1,139,228 (D)	2,087,943
Panama Bay.....	842,721	2,260,485
Totals.....	14,274,477	4,432,159

Grand total by dredges to November 1, 1907..... 6 830,372 C. Y.
" " " shovels " " " " .....12.376.264 "
" " " both " " " " .....18.706,636 "
" " " inside canal prism to November 1, 1907.....14,274,477 "
" " " outside " " " " " " ..... 4,432,159 "

The French had reached 17,700,000 cu. yds when the work was parceled out to the six large firms. The company had expended 132,692,655 francs, or $26,538,531. When we have recorded an output of an equal amount of dry work the expenditures of the Government will have reached nearly three times as much.

Praise for Men.—This series of papers has nothing but praise for the men in the ranks and for the captains at the front They belong to the valiant army pressing on for the goal even "though some one has blundered." "Theirs not to question why." For those loyal to our national ideals and working out their realization by the best in them, we have only respect and esteem. Whatever good betide, it shall never reach the summit of the good we will them all. There are whites and blacks wading in swamps with their red-bug sores cased in collodion and varnished with shellac that they may be free of torment; there are many of those who journey to the hospitals and take their 900 quinine grains in thirty days to help the fever fight. For such—reverence. The waiting shovelmen and trainmen are doing their part, too, to the fullest that the conditions provided admit. But why are they all set at this unequal fight? Why are they handicapped so needlessly? Who keeps them thus in a programme so wasteful of the best in health and hope?

PROJECT OF COMITÉ TECHNIQUE.

CHAPTER XXII.

Pacific Terminal Lake and Dams.

The lower valley of the Rio Grande is a great triangular bowl in whose sea rim have been worn two low notches, one where the river seeks the Pacific, one between the sentinel hills of Ancon and Sosa. These are distinct from the savannah north of the haven fronting Panama City. The three-lakes project was simple, but far-reaching, of closing these gaps and impounding in the basin behind a terminal lake through which the largest vessels could freely steam, under whose

A SHALLOW DUMP.

saving waters the fever-laden swamps behind Panama would be drowned quickly and forever, and by whose plane the necessity for digging deep into the submerged rock would be eliminated. The majority of the board adopted and endorsed the feature in the advised 60-ft. design, which they commended as the best lock canal for Panama; the size-bewitched Minority and Commission took it also into their 85-ft. project, but in such excess as changed its saving grace into a bane. The import of this terminal lake principle was pregnant to the canal, and, its content once

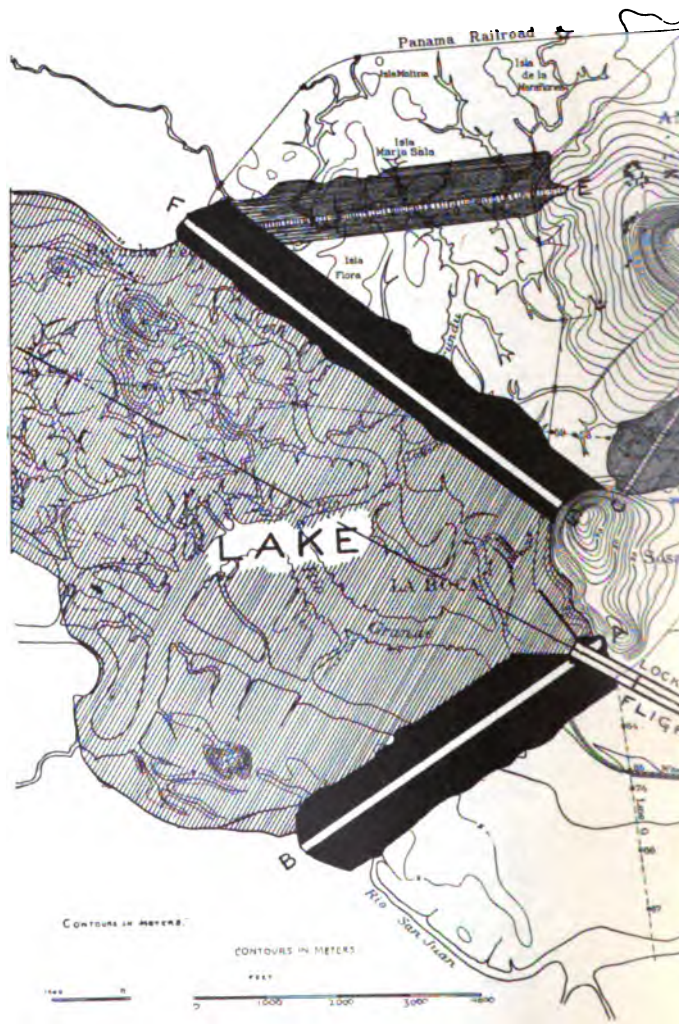
clearly disclosed, its adoption in some form was hardly avoidable. Its plan as introduced into the Lake project submitted to the International Board by the author showed the gaps closed, one by a low dyke and the other by a low rock-founded masonry barrage, through whose ample sluices the lake level was controlled. The lake was set at 26.5 ft. above mean sea level. A primal reason for selecting this plane was that under it the greatest head upon the dyke became 36 ft.; i. e., 26.5 ft. plus the standard tidal fall, 9.5 ft., equals 36 ft. One lock a thousand feet in minimum usable length, imbedded in the rock of Ancon or Sosa Hill gave access to it. The low head of water put the practicability and security of the La Boca dyke beyond question. The combination was a safe, conservative and adequate engineering conception and the Majority incorporated it as proposed.

Seven Demons Entrained.—Another primal reason for adopting the lower plane was that owing to the smallness of the containing dams, at the earliest possible moment and with the minimum amount of work, the deadly swamps of the Rio Grande back of Panama could be submerged. Six months of time and less than a million of money would transform these breeders of otherwise unconquerable Chagres fever and malaria into the bed of a clear, fresh lake, and the death-giving morasses would be replaced by the life-giving waters. The 55-ft. lake involves many years of delay and nine times the quantity of material in dams.

An initial mistake of the Government scheme, one which entrained the fellowship of the Scriptural seven demons, was the raising of the terminal lake to a height over double that which had been for such comprehensive reasons established in the Lake design.

Lake Panama—a lake 26.5 ft. above mean sea level—was lifted to 55 ft., and was rebaptised "Lake Sosa." The nomenclature by this grace differentiates the Government plan.

At its more than double height the impounded waters went above the rim of the natural basin of the Rio Grande, west of San Juan Hill beyond La Boca, and also east of Ancon Hill. Therefore in place of the two low sufficient dams of the original Lake plan a series of huge dams and one small one became imperative to confine their high,



MAP SHOWING THE LOCATION OF DAMS IN THE VICIN
CHANGES OF I

TY OF LA BOCA FOR THE 85 FT. PROJECT WITH EC. 17, 1906.

deep lake. This was the first satanic attendant. One of the three dams had to be interposed at Corozal, between the lake and the City of Panama. This was a second sinister presence. Then for raising ships to the 55-ft. elevation two locks must be intervened in place of one, and these two again, owing to the conformation, must be set in the arrangement which experience has shown to be the most perilous possible, namely, in flight. The third and chief demoniac was introduced. The high lake, besides, wiped out the Panama Railroad, which must be rebuilt at a great cost further up the eastern hills, and a fourth wraith of destruction had joined the train. This initial error at Panama was the inauguration of an engineering eccentricity, amazing at every step across the isthmus.

In examining in detail these features in the Pacific section, the high-level dams come first to the discussion. What are their elements? Of the three shown in the Minority and Commission plan, one is located across the mouth of the Rio Grande river; one between Ancon and Sosa; one directly behind the city of Panama, stretching from Ancon to Corozal Hill. Each crest was to be 90 ft. above low ocean level. The combined crest lengths, since the rim of the bowl must be artificially raised for long sections to bring it above the 55-ft lake, were 12,150 ft.—over two and three-tenths miles.

Guessing Methods Continue.—The commission, on the advice of the chief engineer, in September, 1906, substituted a dam, about 6,600 ft. long, between Sosa and Corozal for the shorter dams of the experts' project. This substitution is shown on the drawing presented. It diminished the total crest lengths but a few hundred feet, and did not materially reduce the "estimates" of quantities or cost.

Further, this new dam, conjectured to cost "$1,349,250," was recommended and adopted without the data of a boring on its entire site. Photographs are in hand showing that the boring party subsequently to this had just entered the verge of the swamp a mile and an eighth wide. So the guessing methods and experimental locations of this Panama directorate continued. Why not, with the illustrious examples of "great" experts and the quality of engineering which is honored and called back at Washington?

In considering factors of safety it becomes momentous, first of all here again that the foundations are alluvial. To

the engineer this means that there arises at once very serious misgiving about a head of 55 to 65 ft. permanently against such long dams and sub-soils, under the exceptionally adverse conditions obtaining at the tropic Isthmus.

A low dam, if suitably constructed, can be safely built; there is no question of this, when such practical examples

CENTER LINE OF DAMS FROM SOSA TO COROZAL.—
BORING PARTY IN FOREGROUND.

as the levees on the Mississippi soil, the dykes on the sand of Holland, or the Assuit Barrage on the silt of Egypt, are visual demonstrations. But when the growing menaces of 50 to 55, and even at low tide, 65 ft., under

treacherous conditions are incorporated, the conservatism of dams on such foundations is left behind. The realm of questionable experiment is entered and the canons of safe engineering are abandoned. The Senate Committee went into extensive examinations of this general question of the security of earth dams on alluvium under high head in Isthmian contingencies. The unequivocal testimony against them of Messrs. Burr, Parsons, Davis, Menocal and Wallace of America, Quellenec of the Suez Canal, Hunter of the Manchester, Tincauzer, the German delegate; Guerard, the French, and Welcker, the Dutch, was collectively set forth in connection with the Gatun dam.

What Would It Be at Panama?—It is to be remembered that the stake in our Panama Canal is great. The Isthmus will be the focus of a world trade, the fulcrum of our naval power, and the vantage point of safety to our coasts. Nations bid fair to have navies of Dreadnoughts, and the perfection of nautical engineering will reach the triumph of a 1,000-ft. ship. These ships in numbers will be with us in less than a generation. Through them and before them, the Atlantic will have become but four days wide; the Pacific but a week wide. Each vessel may be carrying the numbers of an army.

When last year the Suez was blocked for ten days by a burning oil vessel, the whole Orient was stricken—the heart for the time ceased, the coursing vessels in the sea-blood stopped and gorged—all this with only a ship sunken in mid-channel. What would it be instead at Panama, if some day, somehow, somewhy, somewhere, the Gatun dam or a Pacific dam be undermined, and with a roar the greatest water-burst of time rushes to meet the Mother Ocean? At Suez, the waiting shipping knew it was but the matter of a few impatient days. But at Gatun, could or would the dam ever be put back, back over the geologic gorges swept clean then to their profoundest depths? One may play with fire in little things, but not when the nations of the world are made the very tinder for such conflagration. At the Gatun dam are all the factors, the deep pool below the foot, the previous and artesian strata impossible to curtain off, the elements of undermining and uneven settlement, the erodable mass, the inadequate spillway, the deluge-receiving watershed, and the imminent high lake. The

Atlantic section of the waterway was thrall to the high Gatun dam.

Sinister Reminders of Perils.—The Pacific terminal section of the 85-ft. canal is thrall to other high dams, built, like the first, upon alluvium. If these structures, for their ordinary duty and service are by the collective technical judgment above noted most earnestly questioned, how would they meet extraordinary duty or service? Casualties, among other things, will be incident to possible breach in the dams themselves. Breach may arise from several sources. One of these is, of course, earthquakes. The displaced and distorted rails of the Panama Railroad, the ruined cathedral tower at Panama City, the volcanic pits made at Bocas del Toro in 1888, and the crevasses opened near Colon, are evidences too tangible to be lightly explained away. If later testimony is needed there is a sinister reminder: "Colon, July 29, 1906.—A slight earthquake shock was felt here at 6 o'clock p. m. yesterday."

No structure whatever is earthquake proof. In view of the haphazard miracles of survival at San Francisco, and the equally haphazard miracles of disaster at Valparaiso and Kingston, the stock references to the escape of the "flat arch" of the cathedral at Panama as a convicing argument that the locks and dams of the Isthmus will prove immune is as puerile as it is unworthy. The proportion of peril and of damage possible is the only standard for earthquakes. A rift or crevass in a dam under a 65-ft. head—indeed, under any head—must be quickly stopped, otherwise the water would speedily scour and eat through it in a torrent. The contingency is to be well cousidered, because the very special handicaps to repairing the high dams, owing to inaccessible material and the length of time needed, become momentous here.

The Pacific dams of the 85-ft. scheme may be breached not alone by an earthquake, but by overtopping; by unseen undermining; by subsidence; by pressure occasioning a dislocation, or by any other of several causes. The distinct probability of dislocation or subsidence from the mass and pressure of the projected dams at the Isthmus was testified to with ample warnings in the Senate examinations. Pages 1538, 1635, 1798, 1801, etc.

One must contemplate, therefore, with especial disap-

PANAMA CITY.

proval and anxiety one of these questionable dams, lowering directly back of Panama City, holding a wall of water there in perpetual menace. With a rupture in this dam under the eating scour of a 55-ft. lake, an avalanche of water would overwhelm the community in a catastrophe which would leave only a chasm to mark its path.

Panama City is equally the objective for a break in the Pedro Miguel dam far up the canal, or a vessel overrunning its lock gates. Gatun Lake, 171 square miles in area, pouring its volume into Sosa Lake, of eight square miles, might top or breach the Corozal or "new" dam and the down-rushing water would likewise sweep the city before it in consequences too fateful to contemplate. These are possibilities that must be callously acknowledged and accepted if the final and fateful decree is that the summit lake of 85 ft. shall be combined with Lake Sosa at 55 ft.

Every Structure a Vulnerable Point.—This casualty of a Pedro Miguel dam or lock accident is one which must be squarely faced and, so far as possible in all canal dispositions, discounted. In the Panama situation it is undeniable that each and every structure is a vulnerable point. In the present official scheme on the Pacific side one lock at Pedro Miguel separates the upper Gatun Lake, 27 miles long, at an 85-ft. level from Lake Sosa, five miles long, at a 55-ft. elevation. It is so much within the bounds of possibility, even probability, that an accident may cause the breakdown of the lock gates involving the safety devices at Pedro Miguel, that such a misadventure must not be fatuously ignored. Accidents are not considerate. At the Soo Canal lately the mere suction of the lock-filling sluices has compelled a mandate to approaching vessels to moor at a safe distance. The currents induced by a gate disaster would wrench everything floating from its moorings and convert them into whirling, plunging rams. The consequences of this particular accident at Pedro Miguel may be so momentous and appalling that they are certainly to be openly discussed and, so far as may be, provided against. With a break of the Pedro Miguel lock gates and the jamming or failure of the safety devices, the summit Lake Gatun, 171 square miles in area, must come rushing down into Lake Sosa of eight square miles in area, adding the further stress of this accumulating flood. The escape of one foot in Lake

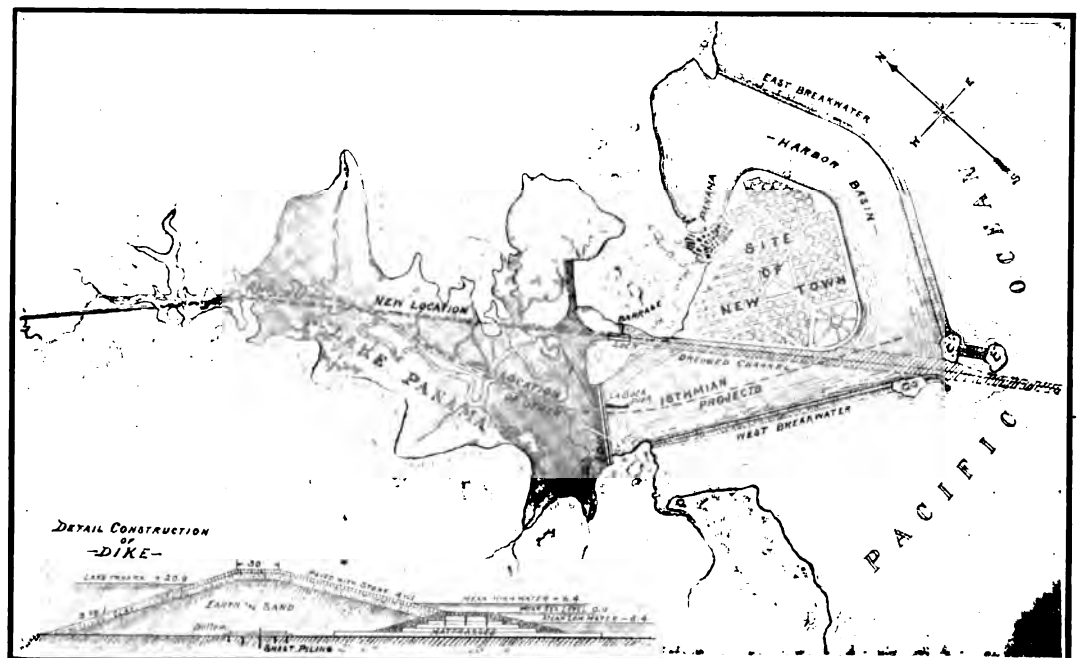
Gatun would suffice to raise Lake Sosa about twenty feet. The thirty feet of difference in elevation of Lake Gatun would suffice to lift Lake Sosa over 600 ft.—to over-top its three Pacific dams a dozen times or more.

This gives some conception of the amount of water this Pacific situation involves. Accumulation dare not be hazarded because the 55-ft. Lake Sosa is above the natural defenses of the hills, and Panama City right under the breastwork is at the mercy of the Corozal dam. One of two outlets therefore must be at once provided—either the western dam across the Rio Grande must be desperately dynamited and a safety channel made there, or the Sosa locks must be opened. But opening the latter would be soliciting a further disaster, for the cataract of such a volume falling the height of the first Sosa lock would speedily tear out the lower lock and the whole flight must go the way of destruction. The official plan provides practically nothing to interpose safety till the upper lake had all but emptied itself into the Pacific Ocean. The velocity occasioned through the Culebra cut must be one absolutely destructive to its unlined slopes, which must be undermined, thus toppling the flanking hills down into the channel beneath. The canal would be ruined—with Culebra swept to Ancon. The entire Pacific section of the waterway, with its immense system of locks, and the Culebra division, which will have cost a treasury, and the city of Panama are thus seen to hang on a missed signal at one gate.

Is the engineering of the combined Minority and Commission and Secretary of War to repose in such a suicidal solution as this for a world canal?

Courting of Cataclysms Eliminated.—When the level of the lake is lowered to the 26.5 ft. originally proposed, this courting of cataclysms is eliminated and the consequences and even possibilities of an accident are largely done away with. The undermining of these vast high dams, not difficult under a 55 to 65-ft. head, is for practical purposes impossible with a scientifically built dyke and rock-founded barrage required to stand against only a low head, and provided with ample and adequate regulating works.

In case of earthquake high earth dams pressed by a 55 to 65-ft. head would surely be much more susceptible and perilous than a low dyke and a low rock-founded barrage. In the other case, that of a fatal breach, the results



LOW LEVEL, LAKE PANAMA. BY LINDON W. BATES.

with the dyke and low lake could not for an instant compare with the high lake disaster. A breach in the high Corozal dam means a repetition on an absolutely unparalleled scale of what befell at Jamestown.

A break in either of the two low regulating works would, if such could occur, only let the lake pour itself directly into the sea, far away from Panama City. But a serious accident against these advised low structures is impossible, because while the high dams are earth and without sluices, the low masonry barrage was especially designed with sluices to cope with contingencies, and, lastly, because the low level of the 26.5 is below the natural line of the encircling and safeguarding hills.

The low Lake Panama is therefore self-evidently for very many and vital reasons a restoration, which the first and barest consideration of ordinary safety dictates.

SELF-PROPELLING, LOADING AND DISTRIBUTING DREDGE, GALVESTON.

CHAPTER XXIII.

Military Aspect of End Locks.

It is held to be the legitimate conclusion from analysis, that any and every canal here is in a military sense vulnerable in so many ways that it is a serious mistake to sacrifice to a hypothetical military benefit, which in reality does not exist, the highest commercial service of the waterway.

One variation of the Minority plan proposed by the retired chief engineer and seconded by the Secretary of War a year ago, would move the Ancon-Sosa terminal locks to Miraflores. Having moved the Pacific locks, the canal is judged safe when in the centre of three lines of possible fire and when on the Atlantic side there is a huge staircase of three locks, making a target four-fifths of a mile long and 360 ft. wide in Gatun Hill fronting the Caribbean and only 3 miles from Limon Bay.

The then chief engineer testified as follows, before the Senate Committee, subsequent to his letter of January 26, 1906, to the Commission:

"I proposed about the same elevation—I think I said 80 ft.—for the high-level canal, as is proposed in the Minority report, and I proposed putting my entire lockage system at the south of Pedro Miguel and Miraflores there together with this idea in view: That the locks at that point will be from the nearest point where a ship can lie, providing she reduced the fortifications in the outer harbor. In other words, she would come up the mouth of the canal and could lie there, but she would have to throw a shell eight or nine miles before she could strike anything that she could damage.

The same condition prevails exactly on the north end, with the dams at Gatun. It is about 8 or 9 miles to where a hostile ship could lie unless she came directly into the canal. She would not have anything to shoot at. My notion is that, with a small object like a lock lying at an unknown point—unless the enemy had absolutely correct charts—a ship would have pretty hard work to do any damage at that distance."

Another Remarkable Proposal.—The supposition that, "after the harbor fortifications were reduced" the war vessel would not enter the canal, but would lie off only "8 or 9 miles" and shoot fatuously into the jungle is surely interesting as a warrant for spending more millions than Alaska cost, to dig through a slime-covered morass and the buried

rock-ridges of the lower Rio Grande valley. The practically minded Admiral or General who "reduces the harbor fortifications" of Limon or Panama Bay will reflect that he does not then need to shoot at locks, but rather must hasten to save them from the defenders, as the Japanese tried to save the docks at Dalny.

Another proposal made by the Secretary of War (vide letter transmitting Board Report) was to slew the Sosa locks in behind the hill so that they became nearly at right-angles to the line of the canal. Certainly this is a remarkable proposal from an engineering and navigating standpoint.

It is time, surely, to reflect. There are no mysteries in the science of military offensive. Every admiralty will know to a dot just where the locks are, and precisely their relation to the zones and angles of fire and to the principal modes of attack from the bays. There are four ways that locks can be disabled from the sea.

1.—By gunfire.

Noting the progress of the past decade, the power of the present 12-in. and 16-in. guns, the constantly increasing range, the terrible accuracy developed, and the certainty that range and accuracy will increase, it needs small prevision to register the fact that the 3 extra miles from Mindi to Gatun or the 4 extra miles from Sosa to Miraflores offer no tangibly greater security at the latter places from a 12 or a 16-in. gun shooting 10 or more miles.

Refused to Take to the Hills.—It is well to note that the ex-Commission, including four members bearing in their titles the evidence of military training and one actively experienced in defending the siege of Vicksburg, agree with the Board and Minority in not taking to the hills at Miraflores to "hide their locks."

2.—By dirigible balloons.

What does it matter to the new French dirigible dynamite airships, one of which lately circled over the defenders of the border forts of Germany, whether their objective lock is on the shore or a few miles from it? A hostile fleet, without "reducing the harbor fortifications," could send fifty such balloons over any part of the canal's 47 miles.

3.—By submarines and torpedoes.

These constantly improving weapons of naval warfare. in daring hands, may be utilized. The locks most exposed are those of the Minority at La Boca, because attacks could be launched from a wider zone. A lock between Sosa and Ancon is partially defended on the flanks. By far the best defense from this sort of attack would be the breakwaters inclosing the harbor. These breakwaters would compel such attacks to run the close gauntlet of the channel between the islands, and an effective boom across the entrance can be stretched. The other plans omit the breakwaters, and their locks cannot so well be defended by booms, nor can the enemy be so easily frustrated.

4.—By stone ships.

The breakwaters likewise are evidently a better protection against these desperate ventures for blocking the channels than the meagre provision of both Board schemes and the last proposal set forth in December, 1906. The breakwaters force such craft right between the point-blank crossfire of the island forts.

The true policy, military as well as commercial, is to build the best canal that science can evolve for navigation, and hold this Isthmian gateway of the western continents. Make it of such nature that its risks are averaged over a number of easily repaired units, not concentrated, as in one huge dam or flight of locks. Make the breakwaters and the inner fresh harbors; fortify the terminals and salient land points so effectively that the United States cannot be dispossessed. The millions proposed to be invested in making a worse canal will be better employed when dedicated to creating suitable naval stations at each end and defenses that cannot be reduced.

"Unable to Find a Location."—But again the Secretary and the chief engineer both reckoned last year without knowledge of foundations at Miraflores. A few simple borings brought forth the following from the retiring chief engineer:

Culebra, C. Z., August 23, 1906.—Chairman Isthmian Canal Commission, Washington, D. C.: Sir:—In the matter of a decision as to the location and general arrangement of the locks and dams at the southern terminus of the Panama Canal.

The question, as you are aware, was some time ago raised as to whether it would be expedient to extend the sea level approach to these locks and dams some distance inland from

La Boca, and to locate the locks and dams at or in the vicinity of Pedro Miguel, Miraflores, or at some adjacent point, but as I advised you in the report yesterday, I have been unable to find a location where these locks and dams can be built that will afford stable foundations.

At Pedro Miguel there is an excellent foundation for one lock; that is, for a lock 1,000 to 1,200 ft. in length, at the elevation which is necessary for the highest lock. Therefore, my recommendation is that, with regard to the location of this lock at Pedro Miguel, the Minority report of the Board of Consulting Engineers is correct, and its recommendations should be adopted. * * * *"

So it appears that there is a rock foundation for one lock only at Pedro Miguel and none at Miraflores. The authorities are brought directly to the point of putting at Sosa Hill one separate lock and a 26.5-ft. lake, or two and a 55-ft. lake—because, forsooth, there can be no other combinations.

CHAPTER XXIV.

Cost of Pacific Section.

Though the case for a low level Lake Panama might rest with the demonstration of its pre-eminence in the single point of technical superiority and security, the added considerations of facility of construction and lessened cost of execution compound its claims. It will become patent upon presentation of the facts that the scheme of high Pacific dams for a 55-ft. lake breaks down in the test of construction cost as well as in that of desirability.

For comparison, the quantities that go to make up the impounding structures of the high Pacific lake may be measured against those which fulfill a similar duty for the lower lake. The 55-ft. Sosa Lake dams are 90 ft. above low water and 1,180 ft. wide at the bottom. Contrast to this the small works which will impound the lake at 26.5 ft. To create the low level lake with safe impounding structures there is required but one-ninth of the material demanded by the other. Then again the 55-ft. lake level is so high that the natural hill rim of the Rio Grande basin must be raised. So that the crest length of the three huge dams of the Experts was no less than 12,150 ft., over 2.3 miles. For the lake at the 26.5-ft. level the two natural gaps alone need be closed, involving a dyke and barrage totaling 4,950 ft., or two-fifths of the crest length required by the higher lake. The import of these factors is that to impound the 55-ft. lake no less than 12,280,000 cu. yds. of earth must be slowly heaped up with a cost estimated by the Minority at $3,170,000, or, by a revised estimate, $145,750 less. The impounding structures of the 26.5-ft. lake contain but 1,421,000 cu. yds. of material, or, as was noted, one-ninth the volume, and the cost, including the masonry sluice barrage, is less than one-fourth as great. Here, therefore, on a primary item—the dams—there is an expenditure by the adoption of the high level lake, of four times what the better system would entail.

The next element of excess in expense is that of rebuilding the Panama Railroad far back among the hills. It will be driven from its present site, as this will be flooded out by over 25 ft. of water on the roadbed. Lake Panama at 26.5 ft. does not disturb the present alignment. But with

Lake Sosa at 55 ft. above mean sea level there is, therefore, compelled a great expense for regrading and rebuilding the road along the new location on the hill-slopes between Pedro Miguel and Corozal.

Six Millions Can Be Saved.—These, then, are two items of the large difference in cost weighing against the high lake plan. The additional cost of its three locks over the two of the low lake (a price of one lock), is but slightly offset by lessened excavations. In the two features of dams and railroad the advantage is plain and unmistakable.

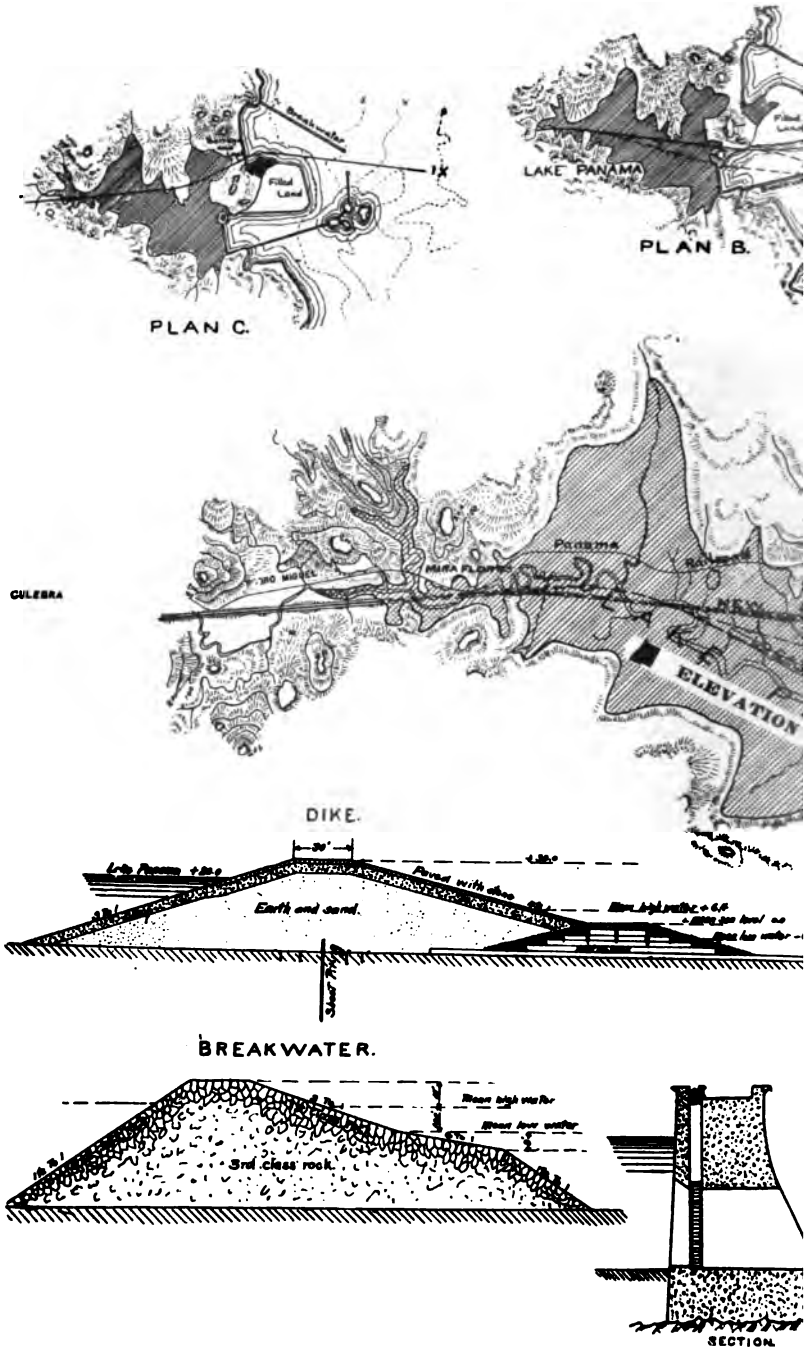
The official estimates of the Minority and Commission for the Pacific section are roundly $26,380,000.

Similarly reckoned, the arrangement with one lock at Sosa and two in the Pedro Miguel-Miraflores section totals $25,024,000, but, as the last paper showed, this combination finds no rock site at Miraflores.

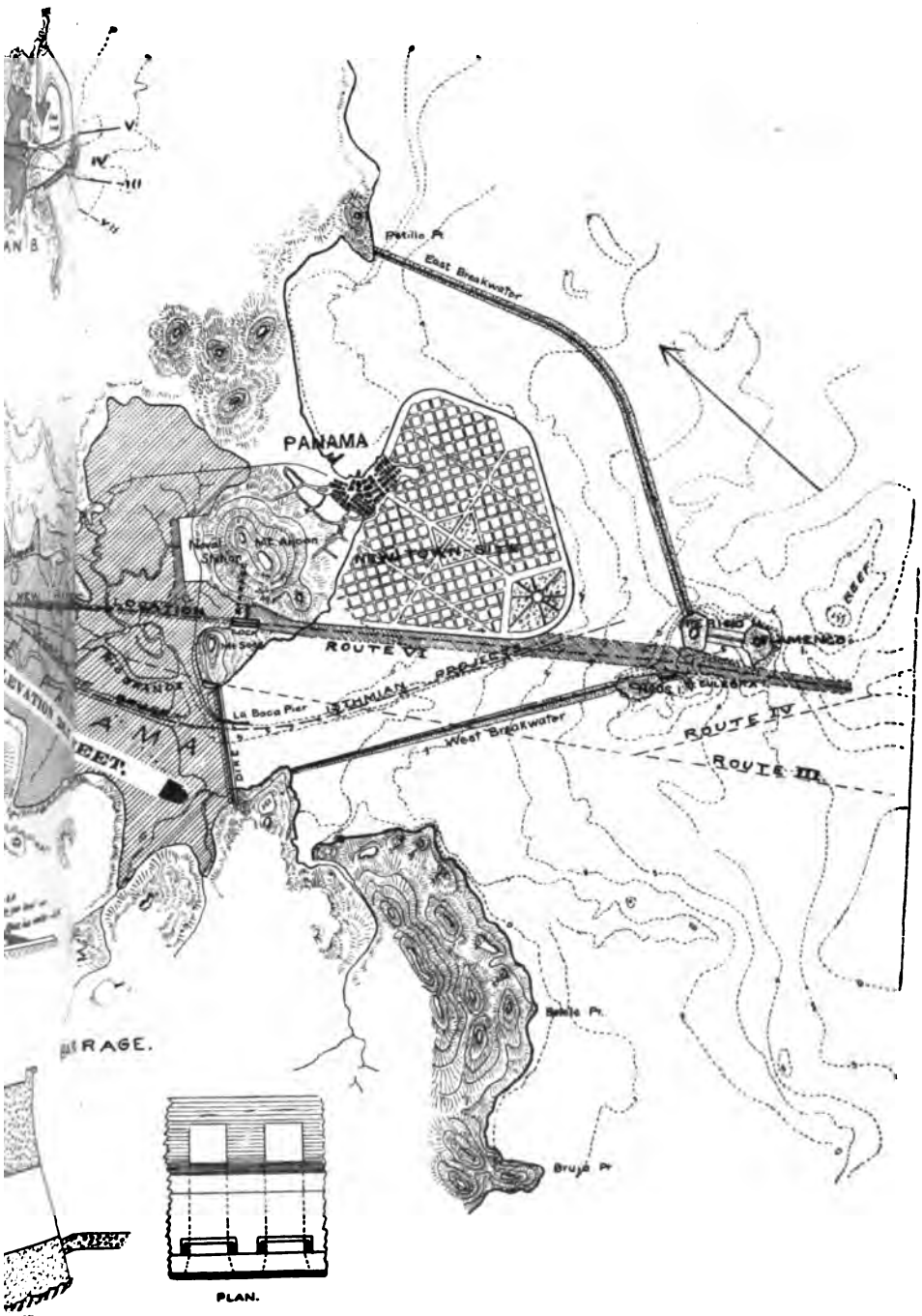
The cost of the low lake system, one lock at Pedro Miguel and one at Sosa, totals $20,209,000—six millions less than the present government plan.

As a matter of arithmetic, therefore, it is conclusive that the adoption of the high level Lake Sosa and its imperative high dams adds over six unnecessary millions to the cost of the Pacific end, even allowing to the proposers the license of their own unit prices for both projects. But for the main structures unit prices will, in fact, be materially lower in the 26.5-ft. arrangement. It costs much less per cubic yard to raise material into a low dam than into a high one. It is a simpler undertaking to make isolated locks than a flight. There is, besides, the practicability of filling in by hydraulic methods, which reduces unit costs to the lowest, while the Lake Sosa dams are to employ experimental processes, which always mean luxurious deficits. So the lower and simpler construction will be built with much greater ease in a few months' time at markedly lower unit prices. Forced by the impracticability of their hydraulic process, Culebra spoil must in the 85-ft. project be substituted and be lifted to fantastic heights.

Right and Best Design.—In the face of such deplorable features as the Minority plan represents here at Panama, it becomes necessary to analyze not alone the low lake proposal, but every other possible substitute. To support at any odds one particular idea would be too much like the



PACIFIC SECTION FROM "PANAMA CANA



STEM AND PROJECTS" BY LINDON W. BATES.

official modus to appeal to impartial minds. It must be neither high nor low—in itself—it must be the right and best Pacific section for the canal. Let us take a complete view, therefore, and pick the best from whatever source.

It is readily seen that for a canal of two or three Pacific locks there are four general combinations.

1.—Sosa lock and one Pedro Miguel lock—the canal herein advocated with the summit level at 62.5 feet, the Pacific section costing roundly $20,000,000.

WELL-DRILLING MACHINE AT PEDRO MIGUEL TAKING SOUNDINGS.

2.—Two Sosa locks in flight and one at Pedro Miguel—the system of the Minority's 85-ft. canal, costing about $26,000,000.

3.—One Sosa lock and two in the Pedro Miguel-Miraflores section, a suggested alternative of the 85-ft. plan, costing $25,000,000.

4.—No locks at Sosa; three in the Pedro Miguel-Miraflores section—the Pacific plan of the 1901 Commission, costing over $36,000,000.

In August, 1906, it developed from boring examinations

that alteratives 3 and 4 above were impracticable, and the chief engineer was obliged to report as follows at the "114th meeting of the Isthmian Canal Commission," Sept. 6th, 1906, whose minutes have been published:

"The question, as you are aware, was some time ago raised as to whether it would not be expedient to extend the sea level approach to these locks and dams some distance inland from La Boca, and to locate the locks and dams at or in the vicinity of Pedro Miguel, Miraflores or at some adjacent point, but, as I advised you in the report of yesterday, I have been unable to find a location where these locks and dams can be built that will afford stable foundations.

At Pedro Miguel there is an excellent foundation for one long lock; that is, for a lock 1,000 to 1,200 ft. in length, at the elevation which is necessary for the highest lock."

Excuse for the Substitute Dam.—Then he points out that the two dams between Ancon and Corozal and Sosa-Ancon interfere so much with the Panama Railway to La Boca that one dam from Corozal to Sosa, costing but a trifle less and just as high would be preferable:

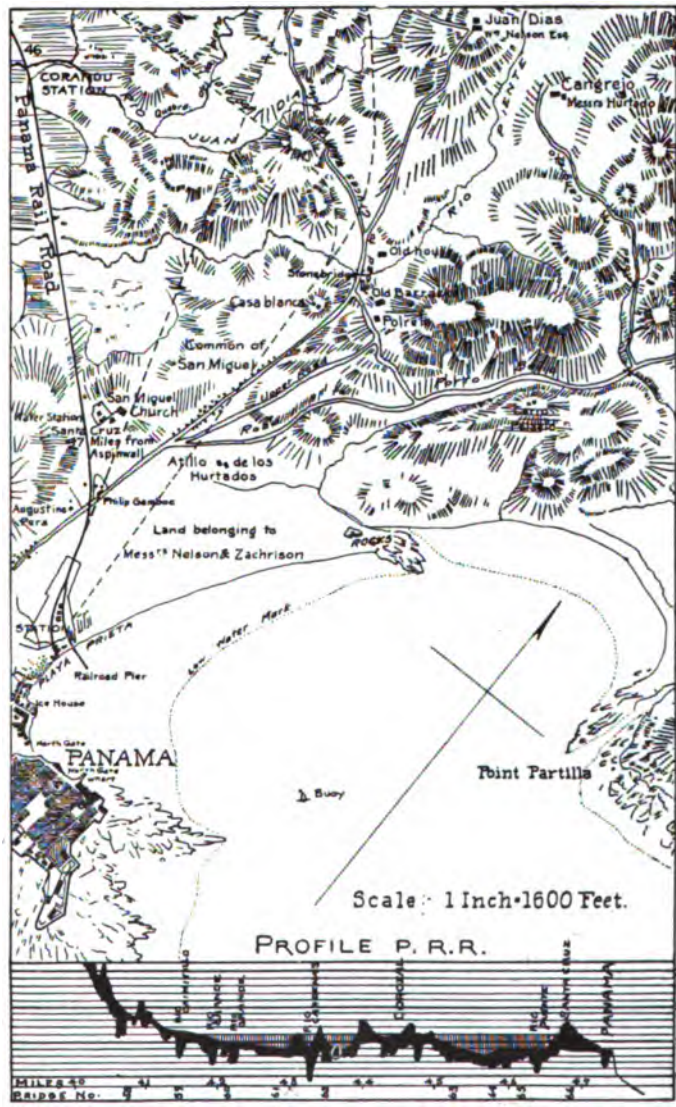
"It will be noted that to adopt the Board's recommendations in their entirety involves the complete destruction of all railroads, yards, shops and buildings at La Boca. It will also involve the abandonment of the Panama-La Boca branch of the Panama Railroad, and will cut off, by way of the north side of Ancon or Sosa Hills, all access of the Panama Railroad, not only to its present docks and terminals at La Boca, but to any docks and terminals which must be established at or near the entrance to the La Boca locks."

"This would necessitate the building of a new line of railway from at or near the railroad passenger station in Panama through a thickly settled part of the city of Panama.

It would be necessary to secure at a very heavy cost, not only right of way for such a spur, but the necessary city property for new passenger station grounds in Panama as well as right of way from Panama through valuable property, the line passing near the cemeteries and through the high point of land which is shown on the maps as Punta Mala.

Such a spur would necessarily have to pass through this point by a long and expensive tunnel in the vicinity of the point marked "A" in order to reach the tide flats opposite Sosa, and even then any plan which could be adopted for the railroad terminals would be very awkward and expensive.

An inspection of the details of the Consulting Board's estimate does not indicate that it took this matter into consideration, as the estimate which is allowed for railroad changes does not, apparently, include any sum for these new terminals and railroad approach thereto."



GRADE-RASING TO BRING PANAMA RAILWAY ABOVE FLOW LINE OF 26.5 LAKE.

He omits to state that with one lock only at Sosa and the lake at 26.5, no change in the alignment of the Panama Railway is at all requisite. He continues:

"I have indicated in dotted red lines on the attached print a proposition that in lieu of the so-called Ancon-Sosa and Ancon-Corozal dams as reported by the Board, to construct a dam from Sosa Hill directly across to the high ground immediately east of the Panama Railroad at Mount Diablo, and which I have marked "Sosa Corozal Dam—new" and I would strongly recommend the adoption of the location for such a dam in lieu of the two dams known as Ancon-Corozal and Ancon-Sosa dams, as recommended by the Board, for the following reasons:

Every result that would be obtained by the dams as proposed by the Board, would be accomplished by the construction of the new dam, with the additional advantages in favor of the latter:

1.—That the margin of the lake to be erected would be kept over one mile further away from Panama and the thickly settled portion of Ancon than the Board's plan, which would be a great factor in favor of sanitation as affecting the mosquito problem."

Swamp Below Ancon Hospital.—He omits to note, as did the Commission, who so dutifully and promptly adopted this curious idea, that there was left east of this dam a full square mile of swamp immediately below the Ancon Hospital, and adjacent to the great nest of cabins where a large portion of the colored inhabitants of Panama hive. The thought that this swamp is more sanitary than a road bordered lake full of fish which live on mosquito larvæ strikes one as very unique. One of the best things the United States Fish Commission could be called upon to do would be to stock the Panama lakes with such fish. The natural freedom of the Barbados Islands from mosquitoes and malaria is ascribed to the "million," a local fish whose mission seems to be to discourage this pest.

Further we quote:

2.—"The adoption of the new plan would render comparatively easy the construction of an entrance and permanent terminal yards for the Panama Railroad and connection between the same and the new permanent docks which I have shown to be located along a basin to be excavated on the east side of the Canal, a short distance below the locks.

"The new Panama La Boca spur, so-called, would leave the present line near Ancon Hill, would pass through the flat ground between Ancon and Sosa Hills where would be located the new yards and necessary terminals of the railroad; thence double track connection is easily established, as shown on the map, to the new coaling or other docks which

must be erected along the line of the canal for permanent use."

3.—After making due allowance for all settlement it is found that the proposed Corozal-Sosa dam will require 5,397,000 cu. yds., which, at 25 cts. per yd., would amount to $1,349,250.

The Consulting Board's figures for the two dams, Ancon-Sosa and Ancon-Corozal, at the same unit price, was $1,495,000; therefore the new proposed dam will be cheaper by $145,750.

I do not believe that one and one-half to two million dollars would any more than cover the expense of securing the right of way and the completion of new passenger terminals in Panama and the building of a new line from Panama outside of Ancon Hill to the new docks, and no plan can be devised which would be, even after this expenditure, at all satisfactory, while the plan as outlined and rendered practicable by the construction of the dam in the new location is extremely simple and effective."

With the lower lake both the second and third reasons, with their millions of prospective expenditures to suit a 55-ft. lake, are quite eliminated. With a full force at the Isthmus the Corozal dam was located quite as of old, without a boring.

"I have, as you will note, indicated the moving of the locks at La Boca about 450 ft., further north, so that the head wall of the upper lock should come practically at the crest line of the La Boca dam. This change will provide just as good foundations and will enable us to provide an approach nearly of 1,600 ft. in length at the southern lock, instead of only about 1,000 ft., as indicated by the plans of the Board."

No Safety Dam at Sosa.—This phrasing abundantly shows that no safety dam is contemplated by this chief engineer to protect the Sosa two-lock flight from the outrush of Lake Sosa in case of an accident. The rock under the lake is deep, probably 60 ft. below sea level, according to boring evidence. It was, however, an object of some concern because Commissioner Harrod presented the following, which was unanimously adopted:

"Resolved, That the chief engineer be requested to consider the advisability and practicability of constructing a basin with walls and gates at the head of each lock or flight of locks, in which basin the lake level will be maintained and all vessels stopped before entering the chamber of the lock, and furnish the Commission with his recommendations and estimate of the cost of same."

It will cost a pretty penny to put concrete basin walls around the lake end of the Sosa lock flight, strong enough to support the lake with 55 to 65-ft. head; to coffer dam and dig down to rock ten fathoms deep in the mud of this steaming swamp.

LA BOCA FROM THE FRENCH PIER. THE CROSS SHOWS SITE OF SOSA LOCK FLIGHT.

There is room on this west side of Sosa Hill for one lock (twin) with a proper safety dam above and ample approaches to either end. There is even a better site on the east side of Sosa Hill and a lesser curvature and a shorter route to deep water.

Further quoting the same chief engineer:

"I desire to call your attention to the fact that a small dam will have to be placed to the west of San Juan Hill. From a reconnoissance formerly made it was thought that the saddle at this point was high enough to retain water at a 55-ft. level. but an accurate instrumental survey shows that there is a slight depression that will have to be closed, requiring about 80,000 cu. yds. which, at a cost of 50 cts. per yd. will amount to $40,000."

This item, however, is common to any project of dams raising the water to 55-ft. level."

It is seen that the 55-ft. lake fills the Rio Grande bowl to the very brim.

Sosa Locks Inaccessible to Large Ships Half the Time.

Then there is another matter connected with the Sosa

locks, which illustrates again the quality of engineering and navigation experience.

The Senate testimony recites (page 3241) recently:

Senator Kittridge—We would like to have for our permanent record all the records that you have connected with this contract.

Secretary Taft—Yes.

Senator Kittredge—If you have not them here, could you furnish them?

Secretary Taft (to Mr. Rogers)—Have you not some other records and correspondence there?

Mr. Rogers—I have here also a general plan for the construction of the Panama Canal, gotten up by our engineers and sent out to bidders.

Secretary Taft—You might give the whole history. There is a letter from Mr. Stevens there, is there not, in the beginning? Was that a confidential letter?

Mr. Rogers—What do you mean?

Secretary Taft—The letter recommending the construction by contract.

Mr. Shonts—That he wrote to me—yes; we have all those.

Mr. Rogers—Even before that we have the first draft that Mr. Brown submitted.

Secretary Taft—I think possibly the Senate would like to have all those things.

Senator Kittredge—We would like to have everything you deem valuable for our information.

Secretary Taft—I will go over it with you and send it up for your records.

Senator Hopkins—We do not want any lumber, though, Mr. Kittredge.

Senator Kittredge—Oh, no.

Senator Hopkins—We want the completed part—the part that the Commission and Secretary act upon.

And on pages 3270-71 appear the official documents for the permanent Senate Record, the public announcement of the intentions of the Secretary of War and Commission:

"The Sosa locks are to be located approximately as shown on Plate VIII. They are to be in flight of two with lift of 27½ ft. each, and to be in duplicate. The details of these locks have not yet been determined, but the following is an approximate estimate of the quantities of material that will enter in their construction:

Excavation (Cu. Yds.)	1,430,000
Back fill (Cu. Yds.)	950,000
Concrete (Cu. Yds.)	992,800
Cut stone (Cu. Yds.)	6,000
Brick (Cu. Yds.)	14,000
Timber (Ft. B. M.)	145,000
Cast Iron (Lbs.)	1,281,000
Steel gates (Lbs.)	87,180,000

Here is a lake 55 ft. above mean sea level—65 ft. above low tide.

The locks are designed with a lift of "27½ ft. each!" For the two locks a total lift of only 55 feet!

Therefore, it is official from the information to bidders and to the Senate that the locks will be *out of service* when the tide is below mean sea-level!—*half the time so far as large ships are concerned.* At low tide there would be 30 ft., not 40 ft., over the gate sill! The range of tide has been quite overlooked. What engineering! What canal service!

As a summary it is clear that in technical superiority and in expense the best Pacific dispositions are attained under a Lake Panama system at an elevation of 26.5 ft., impounded by a scientifically constructed dyke and a safety sluice barrage—the lake to be entered by one 1,000-ft. lock at Sosa and lifting to a 62.5-ft. summit level by the second 1,000-ft. lock at Pedro Miguel.

CHAPTER XXV.

Double Pacific Harbor.

Commodious deep water harbors are vital to the Panama Canal. Such do not now exist, but must be created. The terminal harbors and approaches to the Canal proper should in location and design serve completely the requirements of international navigation, and incidentally those of the Isthmian railway. They should meet the problems of maintenance, and should provide as well the military and naval bases essential to American pre-eminence in the Caribbean and great south seas.

The particular importance of the right terminal harbors has made in this series separate treatment advisable for the Pacific and for the Atlantic sides.

The ruling factors of the Pacific situation concern the inter-relations between an outer harbor in Panama Bay, a possible inner fresh water harbor or lake, the terminal lock, the dams, the piers, new commercial and naval stations, the disposition of the Culebra spoil, and the possible creation of an attractive site for a greater city than the present Panama.

First, the approach channel and harbor conditions must be in harmony with all these elements, as well as with the physical facts. The four islands in the bay and the submerged San Juan reef that lies southeast of the island group are important features in their relation to tidal and littoral currents and to the broken and indented shore line.

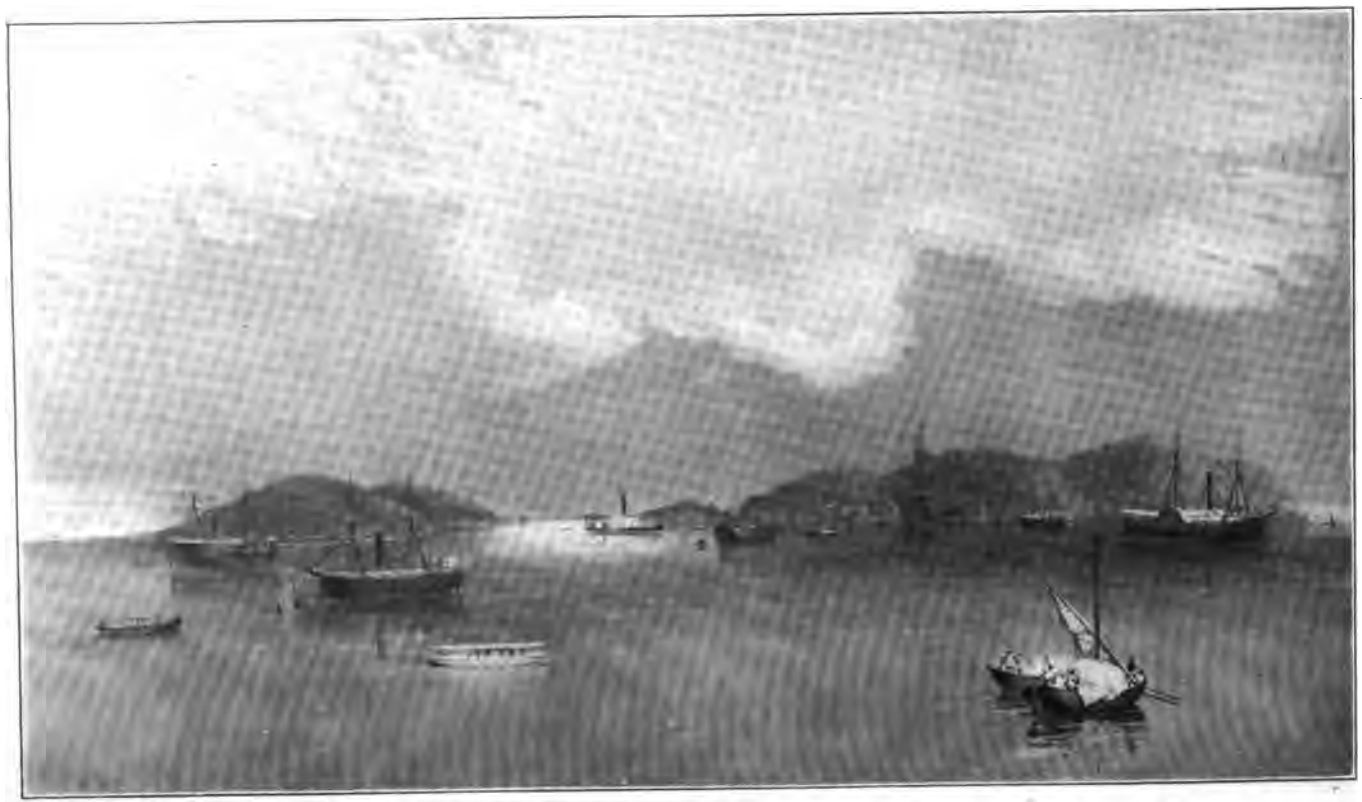
Of particular significance are the following official statements of the Hydrographic office:

"On board ship Panama is the most healthy place on the coast of Central America. Vessels of war have remained here many months at a time and their crews continued in a healthy state."

Pacific Terminal's Sanitary Advantage.—Vessels lying off Perico and Naos Islands in the roads experience fever immunity because of access to the winds and the environment of water areas. The conditions on the islands themselves are identical with those aboard ship. An extension of the Panama town site into the bay would have a similar position and might be given similar sanitary advantages.

The hydrographic record continues:

"The wet season begins in May and lasts until November. The rains gradually increase until the season is fairly estab-



ISLANDS IN PANAMA BAY.

lished in June, and continue throughout July, August and September, with strong southerly winds. In December the rains cease and the northwest and north-northwest winds begin. During the dry season regular land and sea breezes blow. The sea breeze sets in about 10:30 a. m., from the south-southwest. It generally increases with force until 3:30 p. m., when it gradually subsides and at sunset is followed by a calm."

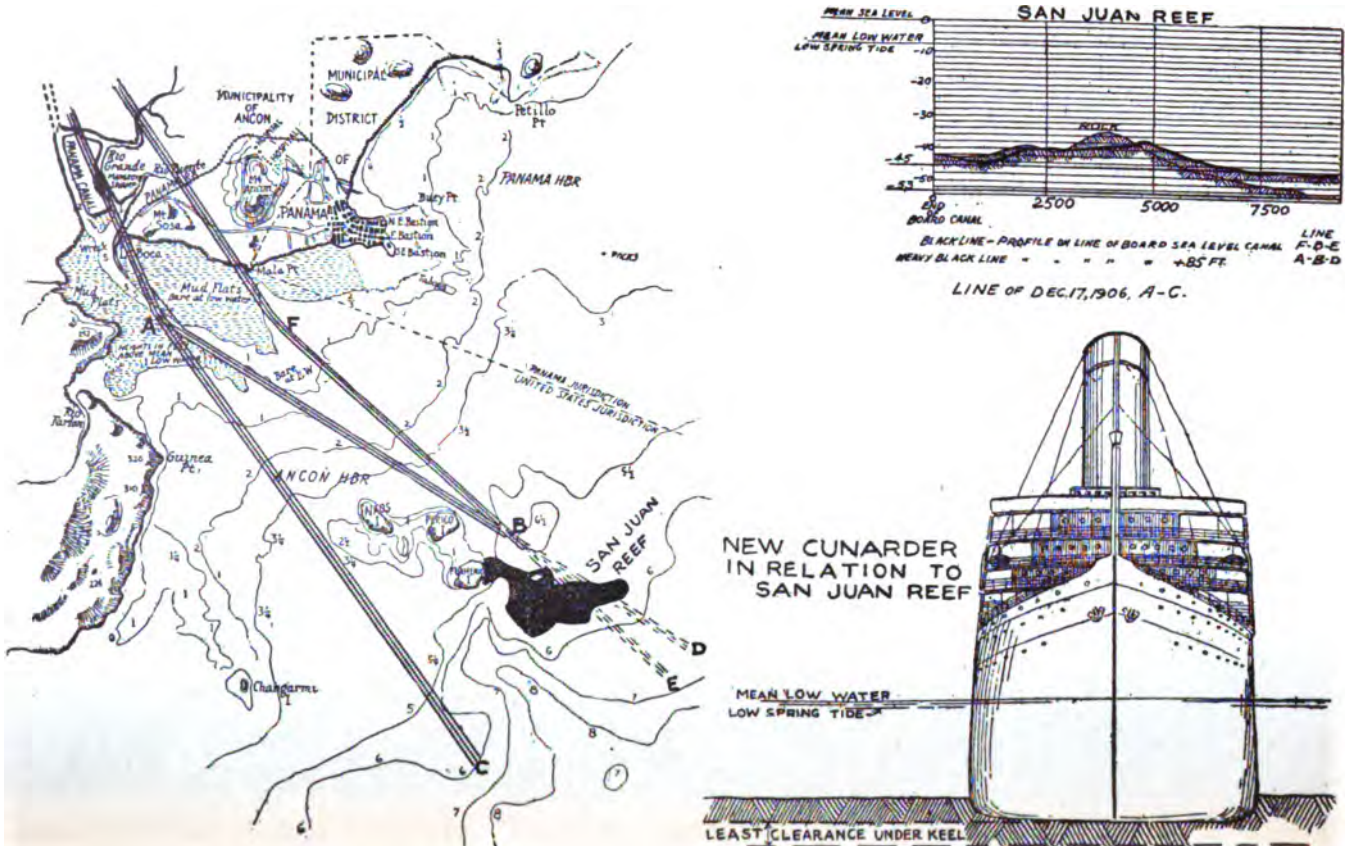
The maximum tidal variation in Panama Bay is 22½ ft. The mean range of spring tides is 17 ft., and that of neaps 7.8 ft.

The ocean currents are noted as being irregular, sometimes to the northwest and sometimes to the southwest. They run from 1 to 1½ knots per hour, following the direction of the land, and make a complete circuit of the Gulf and the Bay of Panama.

The flood tide stream sets in to the northwest and the ebb to the south. This direction differentiates the tidal currents from the ocean currents. Their strength varies from ½ knot to 1½ knots per hour and the ebb is stronger than the flood. A long swell occasionally sets into the roads, but ceases with the flowing tide.

Currents of 2.53 statute miles per hour, due to the tidal prism of the Rio Grande, have been officially observed half way up the present La Boca Channel. These currents in and out of the river adverse to navigation are eliminated if a La Boca dam for creating at the Pacific end a second terminal lake be built. Thus after the construction of the La Boca dam, the ocean and tidal currents will run substantially parallel with the shore. However, in the 85-ft. scheme these, combined with wave motion, will be the constant carriers, keeping up the large drift of sand and mud along the coast and depositing them in the approach channels, which are virtually at right angles to the course of the littoral drift.

Endless Deposits of Sand.—This channel A-C and every other channel from the locks to deep water can be protected from continuously silting up only by suitable breakwaters or jetties. Their office in this bay is not primarily to make areas of calm, because the bay itself is generally calm. It is to combat endless deposits of sand and to change the courses of the swift tidal, shore and ocean currents to lines parallel with the approach channels and not broadside to entering and departing vessels. Their military value also is not to be ignored.



PLAN SHOWNG CHANNELS FROM LOCKS TO DEEP WATER; ALSO SECTION OF SAN JUAN REEF AND CLEARANCE OF NEW CUNARDER UNDER REEF.

There would be a moderate fresh water discharge from the service of the locks.

There may be considerable flow of fresh water into the bay if means are provided for the escape of Chagres floods partially to the Pacific. The fresh water discharge will carry no silt, as that will be caught in the lake areas. The discharge will vary, therefore, according to the rainfall and amount of the run-off which is allowed to reach the sea in maintaining a stable level to the lake.

Sand, clay, mud, volcanic tufa and trap rock are the characteristic formations in the bed and shores of the bay. The Rio Grande has been a silt-bearing stream. Mud, coral and sand and several varieties of clay will be met with in its under water works, but the silt of the Rio Grande valley will no longer reach the Pacific.

Its watersheds and run-off have been so small that this cessation of waterborne silt will not be of material importance to the efforts which will be forever requisite to combat the littoral drift in the 85-ft. plan. Ancon, Sosa and other hills are of volcanic origin. They exist because their rock and indurated mud have resisted the weathering of ages.

45-Ft. Contour Ought to Be Adopted.—Attention is especially directed to the location of the 6, 7 and 8 fathom contours—that is to say, 36, 42 and 48 ft. below mean low water. The 1,000-ft. ship is a certainty of the not far distant future. Having regard to wave motion, to the pitching of the vessel and to the necessity for being able to enter the approach channel with a fully laden ship at the mean of the lowest low waters, the 45-ft. contour ought to be adopted as the shallowest at which to make the seaward end of the approach channel. It will be noted in examining the underwater contours in Panama Bay that a submerged trough trends southeast of a point midway between Naos and Perico Islands, that another heads north of Naos Island, trends westward and then southward, and that a third channel begins at the north end of Perico Island and takes a course a little south of east. The latter is the approach to which the French and the plans of both groups of the International Board aimed. Their shallow channels failed to afford safety to existing ships, let alone to provide for fleets of coming sizes. They failed likewise to recognize that the sailing lines which they proposed passed directly across the San Juan reefs, lying, as has been stated, southeast of Flamenco Island. Issue was therefore taken

two years ago with this latter location by the writer. The Commission and chief engineer accepted the Minority locations and depth provisions, and recommended these with the rest to Congress.

Length of the Troughs.—The summary of the distances from the two principal points whereat the first lock of the canal may be preferably located is set forth.

From La Boca to the 7½ fathom contour these distances are as follows:

Route I., via East Trough, 33,440 ft., 5½ sea miles.
Route II., via Central Trough, 24,320 ft., 4 sea miles.
Route III., via West Trough, 30,400 ft.; 5 sea miles.
Route IV., via West to Central Trough, 25,840 ft.; 4¼ sea miles.

From Reception Buoy below a lock site between Sosa and Ancon Hill the distances run out as follows:

Route V., East Trough, 30,400 ft.; 5 sea miles.
Route VI., Central Trough, 21,280 ft.; 3½ sea miles.
Route VII., West Trough, 30,400 ft.; 5 sea miles.
Route VIII., West to Central Trough, 24,320 ft.; 4 sea miles.

Having regard to distance, exposure, alignment and curvature, it becomes apparent that the central trough is the approach to be preferred, whether the terminal lock be located between Sosa and Ancon Hill or west of Sosa Hill.

The sea trough second in preference is that lying south of the group of islands. This relative desirability was shown on the plate which accompanied the brochure entitled "Terminal Harbors of the Panama Canal," by Lindon W. Bates, published in March, 1905, and referred to on that plate as plan "B." It is the one now "adopted" and set forth in the message of December 17, 1906.

The route least to be preferred and thus superseded—the one striking directly across the submerged San Juan reef—was the approach adopted by the Minority, indorsed by the Commission and advised to Congress by the Secretary of War. The reef and its relation to a liner are shown in the illustration with this paper.

Constant Dredging Necessary.—The general conditions of navigation in Panama Bay and Roads are favorable. The islands and the hills on the mainland furnish conspicuous sites for lighthouses, for range beacons and leading lights. The Roads are shallow and some dredging will be necessary to secure suitable harbor room. If the dredged areas are left exposed to littoral drift and deposits, there will be constant

shoaling in the future, as there has always been in the past. Ever since the La Boca pier has been put into service a dredge has been required to keep its approach channel open. Since the United States Government took over the canal enterprise, this machine has been constantly employed in removing the continuously recurring deposits. The net result of all its operation for the past three years is almost nothing, so far as attaining actual progress upon the excavation of a deep water channel is concerned. Yet its output has been continuously reckoned into the showing of progress and effective accomplishment, and in the official reports of 1906 scow measurement is used to swell the record. The spoil is likewise dumped where the currents will bring it back into the central trough.

As stated in the original brochure, the alternative sites for a first lock are the west slope of Sosa Hill, or between Sosa and Ancon Hill. The latter gives a lesser curvature or change of direction than the former and more rock. Otherwise, there is little to choose between the lock sites.

Chart No. 1042 shows the contours of Panama Bay outside of the islands. This reveals that the approach A-B shoaled beyond the Experts' terminus and that the 40-ft. contour below mean sea level was a mile further out than their plans supposed. This chart was not before the Board, who used Chart No. 1950, which did not contain soundings far enough beyond the islands to disclose this condition on the Canal axis.

Next, 3,500 ft. beyond their terminus, at B, the sailing line prolonged, passed over a rocky reef carrying but 30 ft. at mean low tide. It is some 750 ft. across on the Minority line. The sunken reef runs three-quarters of a mile in a direction 20 degrees north of east from the visible rocks called San Josè. The chart shows it to extend for 900 ft. directly athwart the entrance line. On the sea-level alignment the reef is over a mile wide and is still shoaler.

Axial Line Was Wrongly Placed.—This reef is where there is positive wave motion enough to affect a large and deeply laden steamer. Hence for practical purposes of navigation it may be said to carry under the Minority's plan not more than 25 ft. at mean low tide or 33 ft. below mean sea level, and less under the Majority design. The writer maintained that this axial line was wrongly placed, from the standpoint of the ship's draft and the channel. The Spooner Act

stipulated that the waterway must be safe and convenient and adequate for all existing vessels and for such sizes as shall reasonably be anticipated. The contention was further maintained that the 7½-fathom contour—that is to say, the 45-ft.-contour—below mean low water should be the governing factor.

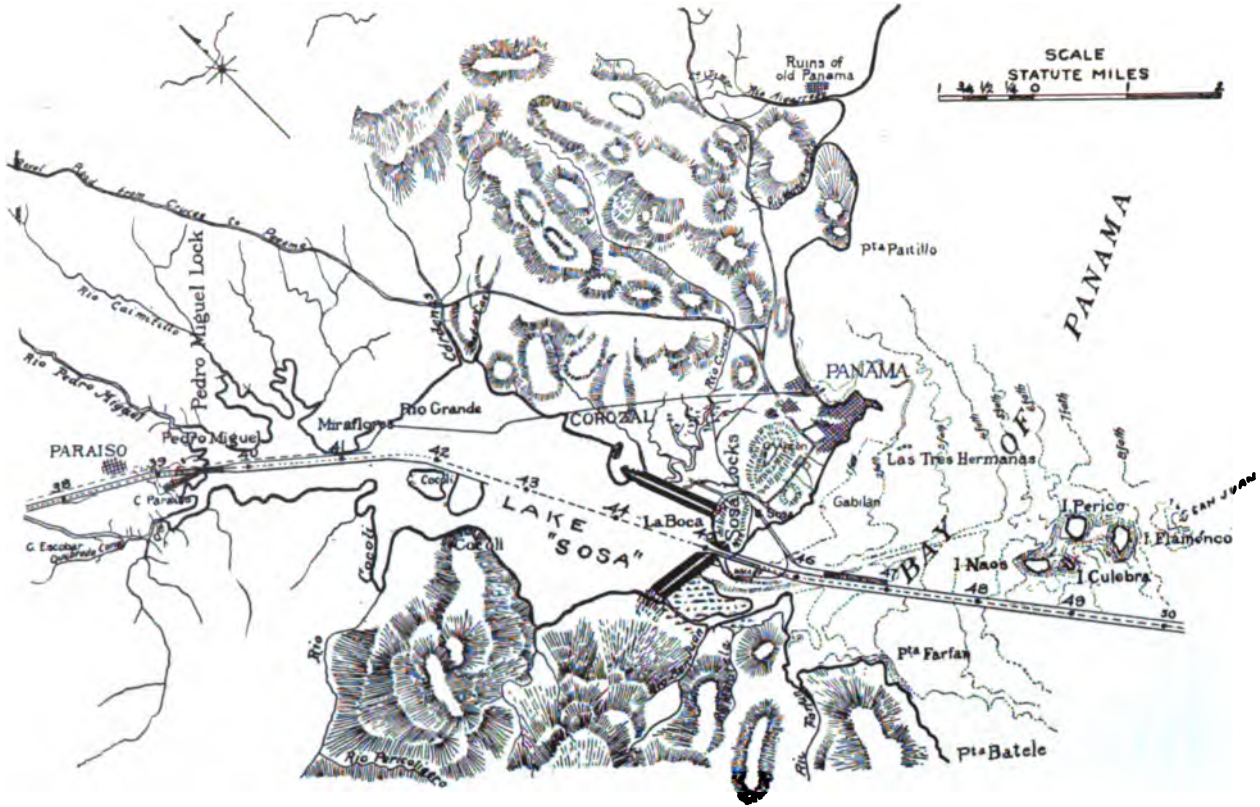
The Advisory Board and the Commission fixed upon the 45-ft.-contour below mean sea level as their basis.

Now, however, after the International plans have been upheld "vi et armis," comes their open abandonment at the Pacific as at the Atlantic end. Expert designing for the canal is held as an aegis before Commission projects, but as has been shown in every leading canal feature, it has been abandoned after later studies. The first announcement of Expert discrediting and overthrow here is given to the public in a resumé of the plans to be executed, dated October 9, 1906. It was intersticed into the second revision of the draft of canal execution proposals. In this official explanation it was set forth that the Pacific approach to the canal is to be made 5 ft. deeper than the Minority and Commission in their shallow channel advised. There must be in consequence material augmentation of "quantities of excavation" in the 85-ft. project as heretofore presented to the consideration of Congress and the public. Nearly a month later comes the corroborating announcement of the message and the map of December 17.

The record of proceedings at the 114th meeting of the Commission in September last show that this south approach, to cost about $816,000 additional, was recommended by the then chief engineer (Page 102) and adopted.

Some Progress in the Right Direction.—In the Pacific features, the latest project differs radically from that proposed by the Minority, endorsed by the Commission and Secretary of War and adopted by the Executive in a message to Congress during the last session. One of these divergent changes is the complete abandonment of the prescribed approach and the location of quite a different one through the Bay of Panama.

The new alignment, supposing it to be finally adopted, is certainly preferable to the line and course projected by the French and later incorporated into the recommendation of the American Commission of 1901, into those of the Minority of the last Advisory Board and into those of the Majority


SCALE
STATUTE MILES
Ruins of old Panama
Pta Paitillo
PANAMA
PACIFIC OCEAN
Pedro Miguel Lock
Rio Caimitillo
Rio Pedro Miguel
Miraflores
Rio Grande
COROZAL
PARAISO
Pedro Miguel
Culebra
Las Tres Hermanas
Gaillard Cut
Gaillard Cut
Gaillard Cut

as well. In so far as it is superior to those selections, it is entitled to and should receive commendation. It is the exact line given second choice in the writer's Three-Lake presentation of 1905, but no breakwaters are provided.

Some progress, then, has evidently been made in the right direction. The channel has been deepened, so that the reproach of having a shallower channel on the Pacific side than on the Atlantic is now *halved,* and the submerged San Juan reef is avoided. For this belated betterment let us give thanks! Perhaps in time the latest approach will also be abandoned for the shortest route via the central trough and between Naos and Perico Islands, which can be better defended from littoral resilting and better protected against a naval attack than any other.

Distribution of Culebra Spoil.—Extending between the "two and three fathom curve" along the latest Panama approach is shown on the official map a new La Boca pier. It is to hold three ships each 1,000 ft. long, and any others that may be waiting to enter the canal or to start upon their long voyage to South American, Australian and Asiatic ports. These must lie broadside to the strong winds mentioned at the opening of this paper and broadside to the ocean, littoral and tidal streams. It was pointed out from the official hydrographic records that these currents attain a velocity of 1½ knots an hour, that is to say nearly two statute miles. Yet this is the full and complete provision made by the Government for navigation. "As the canal will look when it is finished" thus it stands. No breakwaters at all are incorporated as part of the canal plan, either to contend with littoral drift and resultant deposits or to protect ships and the nagivation channel from the consequences of strong and broadside currents. A pier 1,000 ft. long—this is the full story of Pacific harbor provisions on the Panama Canal. Is it not almost incredible? If the waiting ship be berthed on the north side of the approach channel, she must strain at the mooring buoys with a current forcing her to the southward; if she be berthed on the south side with the next tide there will be a current forcing her to the northward and encroaching her upon the navigated track.

Engineering of Landsmen.—This is the engineering of landsmen surely. Let the good that men do, however reluctantly they may have done it, be acknowledged. Something has been done. The worst approach has been abandoned

for a better one. But is it sufficient to have even the second best approach, and can the world's shipping be left to winds and tides undefended by breakwaters? There must be at Panama a commodious and safe harbor. The country and its commerce are not best served by plans that quite

SOSA HILL AT THE LOCATION WHERE LOCKS PROPOSED.

forget the ship and the needs of captains and pilots. It is certainly sufficiently difficult in a 300 or a 500 ft. channel to handle a great liner when the currents are with her. When they are broadside to her course, the quaint provision of the old Belgian Law at Antwerp should be interposed, which forgives a pilot or a captain if he loses his ship at the

Elbow, opposite the Old Stein, because the "devil" is in the water. At the Pacific end of the canal, the devil is not, however, in the water alone. There is surely some serious indifference or ignorance as to what provision is adequate and necessary to the safety and the service of the world's commerce.

Harbor Facilities.

Certain adequate preparations are necessary for the reception of vessels before they can essay the locks of the Panama Canal. The importance of the best approach and rightly equipped terminals which will economize to the uttermost the time of passing ships is radical. One is constantly struck by the very partial view which Experts and Commission have taken of navigation needs. The canal bed itself from shore to shore seems through most canal history to have so concentrated attention that the ships for whose service an Isthmian waterway was being built have been almost overlooked. Although the Spooner Act calls for an adequate and complete canal, save for a new La Boca pier, no provisions whatsoever here, and, of course, as usual no estimates whatsoever, were made for equipping or getting the terminals into readiness for receiving and dispatching vessels. "Breakwaters or no breakwaters," this seems to involve the whole conception of a harbor and its provisioning and incident cost.

Why Harbor Should Be Inclosed.—The harbor of Panama should be inclosed for three reasons—first, as the only way to combat littoral drift and currents; second, as a military precaution; third, to make the nearest safe spoil area for Culebra material. The area inclosed by the encircling arms should be so large that the tidal prism of the basin would create currents parallel to the axis of the navigation track, not broadside to it, as when breakwaters are omitted. These make the safest condition for vessels entering or leaving the harbor. The influence of the tidal prism currents would tend sufficiently seaward from the breakwater heads that when a vessel was approaching or leaving port the ebb and flood would be parallel also to her course, and not at right angles with it.

This ebb and flow of the tidal prism through an approach 800 ft. or 1,000 ft. wide would be sure to keep the entrance free from silt deposits. Such an entrance either looking toward the south or the central deep sea trough would be safe

in the heaviest gales. Waves coming directly into the harbor would be absorbed almost immediately that they entered, and the surges would not strike the ship on the quarter tending to give her a shear, but would be almost behind, or directly ahead, according to whether the vessel were entering or leaving port.

The entrance would be one of the most conspicuous, direct and easy to negotiate in the whole world.

In the best plan, Perico and Flamenco Islands are found making the east breakwater head, and Naos and Culebra Islands are joined for the west head. The east breakwater will require 4,700,000 cu. yds., exclusive of settlement and it provides thus much of a spoil area for the rock of the Culebra section. Its length is 20,700 ft. The west breakwater extends from the west side of the Rio Grande inlet to Culebra Island. Its volume is 2,000,000 cu. yds. and the total length is 13,700 ft.

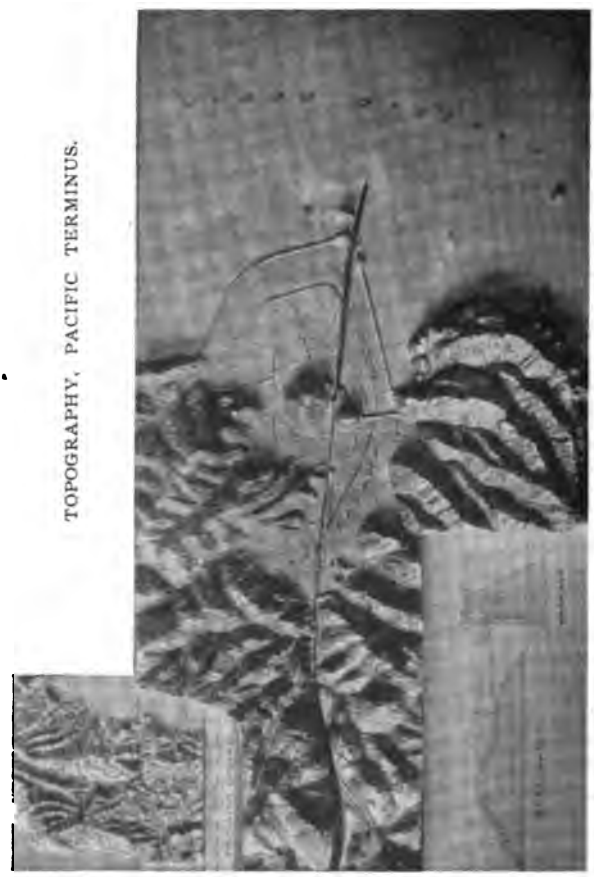
One of the greatest problems at the Isthmus is that of transportation and deposit of spoil. The vast Culebra mass must be excavated.

Dumping Grounds for Spoils.—From the Isthmus during the veering days of contract or no contract were sent a succession of messages. Then came the triumphant announcement that 566,000 cu. yds. was the record for January. February 17 came an anticipatory announcement of 600,000 cu. yds. for February and 800,000 cu. yds. for March. It is not whispered, however, that meanwhile dumps have been located in the uttermost convenience for making an exhibit. The haul has been to spoil areas right at hand. The ex-Chairman's speech, it will be recalled, gave as one of the great policies of the preparatory period "that all available forces of laborers should be concentrated upon sanitary work, the construction of quarters and railway enlargement, and the location and erection of dumping grounds for the spoils."

The April, 1907, Culebra record, at the end of the dry season, of "879,527" cu. yds., has not since, to Oct. 31, been again reached. It is the work of dredges in sludge which now swells the welcomed totals. We quote from the "Canal Record" of October 16, 1907:

"It is interesting to compare the output of the dredge Ancon for the month of September with that of the steam shovels. The total amount of material removed by this dredge during the month was about the same as that removed by 14 steam shovels. This dredge dumps at sea all material excavated, carrying it

an average distance of 3½ miles. To dispose of the same amount of material in the Culebra Division, would require about 30 Lidgerwood trains of about 16 cars each per day, together with the same number of locomotives to handle these trains and, in addition, a few locomotives would be required in connection



TOPOGRAPHY, PACIFIC TERMINUS.

with other parts of the work. The entire crew of the Ancon consists of about 57 persons, whereas, to excavate, transport, and dump a similar amount of earth by steam shovels and material trains would require the service of about 1,500 persons."

A new Panama town extension is the nearest spoil site which may be made safely and economically. Its location lies

within the arms of the breakwaters built to inclose a harbor area and a spoil area, each large enough to answer the demands of commerce and the magnitude of the Culebra cuttings. Such a deposit ground can be established and utilized, adding to the domain of the zone, affording a new and better located and ideally sanitary site immediately adjacent to and seaward from the present town; creating an ocean driveway, a park and plaza system, and supplying as well docks and the United States naval station, so supremely desirable here.

The Rio Grande swamps should not be covered with Culebra material. It should be deposited nowhere in the canal water-shed, unless there is a certainty that tropical deluges will not sluice mud into the channel. No available spoil areas lie on the mainland to the westward of La Boca Bay and one must go to the watershed of the Rio Juan Diaz—6 to 8 miles east of Panama and 20 miles from Obispo to get away from the drainage basin of the canal.

If the material dug be taken by rail to large sea dumping vessels it must then be carried a dozen miles away so as to insure that the strong littoral drift will not bring endless contributions of mud back to the unprotected dredged channels of the Panama roads, as is permitted by all other proposals.

Together the breakwaters will take 7,500,000 cu. yds. of Culebra spoil, adding 10% for settlement.

The Rio Grande dyke will utilize say, 1,000,000 cu. yds. All the balance of the material taken from the summit cut can be distributed for reclaiming land in the harbor area and still have an ample water space.

The town site will possess a very great potential value, because with such a harbor and such a canal as this, Panama must become again the mistress of the southern ocean.

Best Solution for the Pacific End.—As the best solution for the problem presented by the conditions at the Pacific end and the most satisfactory utilization of the natural factors, the plan briefly outlined is:

1.—That the canal line be located from Miraflores, via a lock between Ancon and Sosa Hills, and through the bar between Naos and Perico Islands to deep water.

2.—That extending from Petillo Point beyond the present limits of Panama Haven on the east to the Islands of Perico and Flamenco, and from a point to the west of the old projected canal entrance at La Boca to Naos and Culebra

Islands and including the whole harbor and wharf front of Panama, be built breakwaters of the rock material excavated from the Culebra cut.

3.—That the remaining material from the great central excavation be used to fill in a new town site within the arms of the breakwaters.

4.—That an inner fresh water harbor and naval station be established in Lake Panama behind Ancon Hill.

It has been shown that the central sea-bed trough gives the shortest and most direct approach both to the mouth of the Rio Grande and to the saddle between Sosa and Ancon Hills. A line struck from Miraflores will pass straight through this saddle and between Naos and Perico Islands to the nearest point of the 7½-fathom contour. It will eliminate many degrees of the curvature in the alignment of the canal.

Between Sosa and Ancon Hills, therefore, is the best location for the lock and barrage. These should be combined, because the fresh water discharge can most profitably and beneficially be directed through the channel actually navigated and adjacent to the docks of Greater Panama.

The Divided Lock.—Before the convening of the International Board, locks for an Isthmian Canal had been projected only 800 ft. long. No one had been led before that and no one seems to have troubled much since to analyze the potentialities of the longer lock, which present and coming sized ships have made imperative. But the long structures lend themselves to combinations and designs which make possible large economies, as well as increased safety.

The arrangement in a divided lock is defined in reference to Panama conditions as a lock of, say, 1,050 ft., with a gate width of 105 to 115 ft., into which has been incorporated the following capacities:

1. The main lock is adjusted to locking ships from 575 to 1,000 ft. long.

2. The main lock is so divided that the sub-lock No. 1 will lock vessels up to 475 ft. long.

3. The main lock is designed for the full determined lift, up to 36 ft., as shall be decided.

4. The sub-locks are planned also for full lifts. In transit, ships under 575 ft. may thus pass either way with the minimum use of lockage water. It is estimated that 80% of the number of vessels passing the canal will probably fall into this class. On account of the Pacific tide range such a

type is best for the Sosa lock. This very valuable arrangement and safeguard is impossible in a flight of locks. It is feasible only with separate locks as the Bates Project proposed.

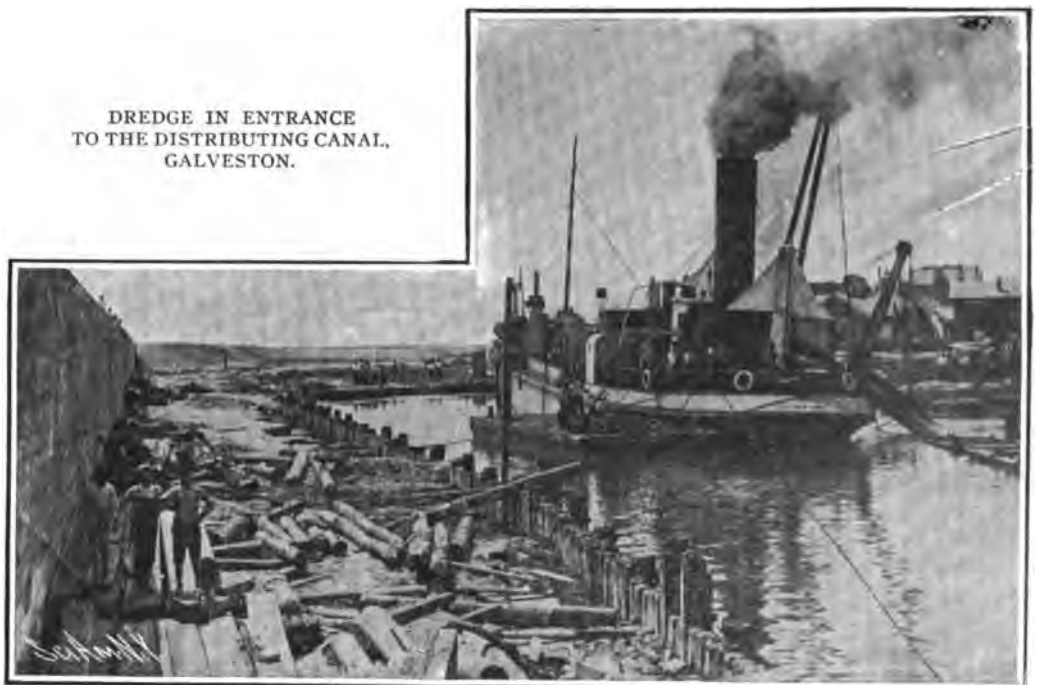
It has been shown through this series that in many salient features of the canal the proposals of the Minority have been rejected and other substitutes interposed, yet these same experts went again to Panama.

WATERFRONT OF PANAMA.

Their entire alignment from deep water on the Atlantic side to Lake Gatun—the approach 4.55 miles, the route from Mindi to Gatun, 2.60 miles—and the position and axis of the locks, nearly another mile, some 8⅛ miles in all, have been abandoned and changed. The "790 and 820" feet of lock lengths have been rejected and 1,000-ft. locks substituted. The width, 95 ft., has been changed to 100, and will doubtless be again increased to 110 or 115 ft. New spillways or dams are found necessary to raise the Trinidad hill-rim.

The Experts' Pacific approach has been relegated to the limbo of things that were, and the line here altered for 5⅛ miles more, making, with the Limon Bay changes, a total of 13¼ miles, or over one-fourth the entire distance across the Isthmus.

The position of the Sosa locks has been modified. Two of the Pacific dams have been thrown out and a long one substituted. All that is left them is the Gatun dam, one Pacific dam and the flight idea. The technical judges selected to pass on these remnants number the old two Experts and a colleague, three and the Secretary. A good augury for a court—a supreme technical court! They went and scrutinized four test pits on Gatun Hill and certified that all their former certifications were unchallengeably re-certified.



DREDGE IN ENTRANCE
TO THE DISTRIBUTING CANAL,
GALVESTON.

CHAPTER XXVI

Conditions of Navigation Alignment and Transit Times.

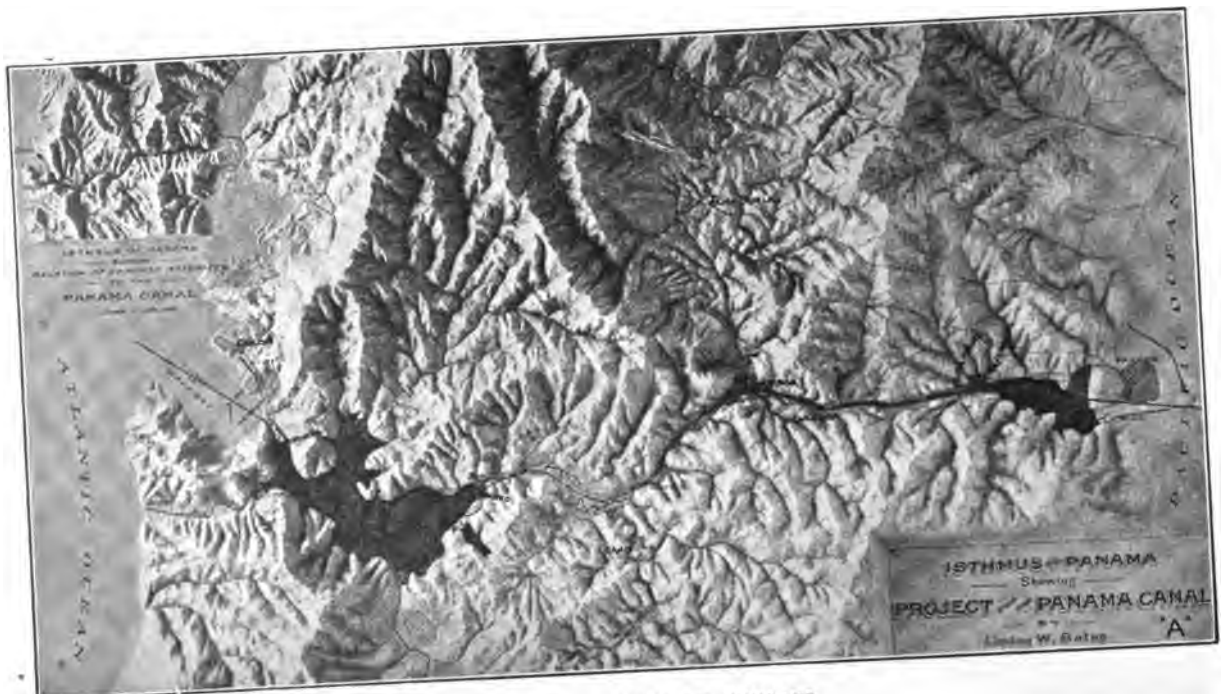
Future Conditions of Navigation.—For the first years which will follow the adoption of a definite canal plan, the principal concern will be with construction and its attendant problems. Afterward, for all future centuries, efficiency for navigation will be the great test.

The Government 85-ft. project has been reviewed and examined to the end of securing the best technical results. It is well to survey the waterway from the point of view of a commander desirous of taking his vessel across the Isthmus with the greatest convenience and safety. His route and his procedure as evolved in the operation of canals in general are sketched for the three-lake, four-lock and the 85-ft. scheme.

Four-Lock Plan.—A vessel coming from the Atlantic side would enter Limon Bay by the channel, making in between Toro and Manzanillo points. Lighthouses and ranges would clearly mark the course. A signaller from the breakwater head would telegraph to the Port Warden the name of the vessel, whose assigned berth would be signalled back as she passed in.

From the ocean the captain would steer a straight course up a wide buoyed channel toward the city on Jaramillo Hill. The ship would pass between the breakwater heads and through the outer salt-water harbor to the assigned mooring buoys, in the reception basin just below the terminal lock. After passing inspection, an officer would go ashore, as is customary, to receive orders and get dispatches, and the canal official would come aboard to measure the tonnage. Meanwhile the vessel might be docked in the salt-water harbor, or pass the terminal lock and come to a wharf or buoy in the inner fresh-water harbor on Lake Chagres. At the terminals, a stay of several hours is always made in such canals.

Coal and supplies are taken on, passengers are transferred, the vessel pays the passage dues and various routine business is transacted. During the necessary stay in port the terminal lock would be passed, so that the time spent in thus doing does not count against the time of actual canal transit. It does so count against transit time in every other



THREE-LAKE, FOUR-LOCK PROJECT.

design proposed for the canal. It is perfectly apparent, and any practical navigator reviewing a chart will agree that these arrangements are the safest from a sailor's standpoint that could be devised. The broad entrance to Limon Bay, the wide channel without a curve, leading into an outer harbor in the head of the bay, engirdled by hills and protected by a strong breakwater; the entry to the canal lock from the reception basin still further in and nestled between Quebrancha and Jaramillo Hills, and then the passage into the fresh-water harbor behind them—all these combine into dispositions which make the entrance easy, safe in any weather and perfect in every detail.

Lock Flight Canal.—On the other hand, following the map of December 17, "how the 85-ft. canal will look when finished," a merchant captain or naval commander will proceed from the sea up to Mindi Point. Beyond or south of this the 85-ft. project runs for over a mile along the shore line with a channel open to sudden shoaling, because it is not protected by breakwaters of any kind. She now enters a stretch of two miles of morass-encompassed channel, through the swamp of the quicksands, and must moor at the foot of the flight, in mid-swamp and in mid-channel as well, since there is provided no waiting basin here.

Some 2½ hours are occupied in negotiating the three-lock staircase, and in mounting the ladder the ship has been in continuous peril. Mr. Welcker of the Advisory Board reckoned this as 2.87 hours. At the single separate lock here of the Three-Lake Canal, one hour or less would have been occupied, and the ship would have been rationally safeguarded all the time.

Gatun Cut-Off.—Next in the Three-Lake Canal instead of following the long sweep of curves over the old river and canal bed which all other projects adopt, the vessel could pass by a new alignment between Gatun and Bohio. This shortens the distance by 1.4 statute miles, and eliminates 76 deg. 36 min. of curvature between Gatun and Bohio. Between Bohio and Sosa the navigation conditions of the two Culebra division plans are essentially the same. The influence of the section from Bas Obispo to Miraflores upon the time of transit and upon the capacity of the waterway for passing vessels depends upon four factors:

1.—There must be a reception and turning basin at the north end of the constricted Culebra division.

2.—There must be a similar provision at the south end.

3.—There must be turn-out facilities—"gares" as they are called on the Suez. At first these should not be over four miles apart, and as the number of ships seeking passage increases, intermediate "gares," or turn-out widenings, must be made.

4.—The length of the narrow rock-walled Culebra section, "200 ft. wide on the bottom and 208 ft. wide at the water-line," which in the 85-ft. and in the four-lock canal is 8 miles, from Obispo to the reception basin above the Pedro Miguel lock.

It has been assumed that all these types and sizes of vessels can pass each other in the steep, rock-walled passage presented by the Board. It has been contended that when ships meet, one will be tied up to the bank; then the other can pass safely. But this all depends on size. Vessels of over 65 ft. beam cannot and will not be permitted to pass each other in this fashion. One or the other steamer will wait at the ends of the Culebra Gorge until the way is clear against meeting another ship, and will then proceed, unless "gares" or widenings are provided.

These turn-outs ought not to be over an hour apart at furthest, that is to say, four miles.

The Lake Canal and fortuitously the 85-ft. have basins at each end, and so require at the beginning but one intermediate turn-out. The Majority and Minority have provided none. The cost, also, which will be high, because the cut is deep, is not included.

Even in a "gare" the most vigorous precautions must be taken to keep the waiting vessel in her position because of the suction of the passing ship. If a large steamer essays to pass another in the main channel here she is practically entering and leaving a lock, except for the time of lift. She must slow down, crawl at a snail's pace and then speed up, while the other has to stop, make fast, wait, cast off and go ahead.

It is and always will be extra hazardous for large ships to pass each other in the main part of this narrow Culebra section.

Consider two vessels of 80-ft. beam. They will be common enough in twenty years. Trace their procedure in getting past each other. One lies 10 ft. away from the bank. Her side is 14 ft. from the center, leaving 118 ft. clearance for the other ship. Remembering the tremendous displace-

ment of water caused by a vessel of large dimensions moving four or five miles an hour and the suction thus set up, this clearance is not enough.

Without "gares" the Minority Channel here becomes equivalent to two more locks than the six they have shown.

This is a navigation and channel capacity question. It is necessary to think sometimes, in a canal whose purpose is commerce, of the convenience and safety of ships.

At Sosa, the navigator meets in the 85-ft. a flight of two locks. His risks and time loss are again proportionately greater than with the single separate lock here of the other design. In the latter the captain would next get his final sailing orders, take on freight for the trip and lock the vessel into the great ocean harbor of Panama, while the passengers were touring the regenerated and expanded city, with a splendid esplanade encircling its great sea front. Receiving the guests aboard again, the ship would then steer out past the Pacific quays and the islands and the Isthmian link be passed.

Saving of Length.—Under the locations of the Government project the length of canal between La Boca pier and the mouth of the Mindi is approximately 36 sea miles. Under the two or four lock design, the length of canal is 33 miles, 5,126 ft. using the Gatun cut-off. Under the Government plan as mapped December 17, 1906, the canal from the deep water contour on the Atlantic to that on the Pacific is closely 44 sea miles. By the two or four lock arrangement it is but 41 sea miles, 5,545 ft. The saving in total distance is 2 sea miles, 455 ft. or over 2 1-3 statute miles!

Comparative Times of Transit.—One of the vital tests of the merits of any plan for the Isthmian waterway is the time of transit. It is axiomatic that the design which creates a canal with conditions of navigation which take a large ship the longest time to negotiate has its utility largely discounted as against a canal which takes the shortest time for the same ship in transit.

The two and four lock projects have the advantage of the Gatun cut-off. The 85-ft. project is calculated on the new alignment to La Boca pier below the lock flight.

It is assumed for all projects that in the channel tangents, the allowable speed for the largest vessels is an average of 4.5 miles per hour, and on curves 4 miles per hour. In the open reaches of lake navigation an average speed for the

SEA LEVEL PROJECT.

largest vessels of 9.5 miles an hour is used with safety.

The time of passing terminal locks is not counted as affecting the total passage period. This course is in virtue of the universal and compulsory custom that ships spend several hours at both termini of such a canal during which necessary period end locks may be passed without any real loss of time. The actual practice of navigators in passing through canals after a long voyage must be the basis. The time is, therefore, reckoned between the actual dispatching stations. Under the two and four lock plans, it is shown that a daylight trip from end to end is entirely practicable and that the Government waterway does not offer this advantage.

Two Lock Project.

	Dist. in Stat. Mi.	Speed, Stat. M. P. M.	Time, Hrs.
Lake Chagres	9.861	9.5	1.038
Channel tangents	11.600	4.5	2.577
Channel curves	10.99	4.0	2.747
Lake Panama	5.248	9.5	.552
	37.699		6.914
Time lost in speeding up and slowing down at Mindi and Sosa			.158
Transit time without meetings			
Channel per cent of length 60			
Lake per cent of length 40			
Meeting in transit			1.380
Total			8.452

Four Lock Project.

	Dist. in Stat. Mi.	Speed, Stat. M. P. M.	Time, Hrs.
Lake Chagres	2.371	9.5	.249
Lake Gatun Bohio	19.559	9.5	2.059
Channel tangents	5.849	4.5	1.299
Channel curves	4.641	4.0	1.160
Lake Panama	5.248	9.5	.552
	37.668		5.319
Time lost in acceleration and retardation at Mindi and Sosa			.158
Lock at Gatun			1.067
Retardation at Gamboa			.022
Lock at Pedro Miguel			1.037
Transit time without meetings			
Channel per cent of total length 28.1			
Lakes per cent of total length 71.9			
Meetings in transit			.61
Meetings at locks			.18
Total time			8.933

Sea Level.

	Dist. in Stat. Mi.	Speed, Stat. M. P. M.	Time, Hrs.
Channel tangents	18.860	4.5	4.191
Channel curves	20.423	4.0	5.106
	39.283		9.297
Time lost during acceleration and retardation at Mindi and Sosa			.075
Tide lock at Sosa			.693
Transit time without meetings			
Meetings in transit			2.15
Meetings at locks			.18
Total time			12.395

TWO-LAKE, TWO-LOCK PROJECT.

85-Foot Project.

	Dist. in Stat. Mi.	Speed, Stat. M. P. M.	Time, Hrs.
Mindi-Gatun	2.600	4.5	0.578
Gatun Lake	20.992	9.5	2.210
Channel tangents	5.849	4.5	1.299
Channel curves	4.641	4.0	1.160
Lake Sosa	5.400	9.5	.552
	39.882		5.799
Time lost in acceleration at Gatun and Sosa			.158
Locks at Gatun			2.870
Retardation Gamboa			.022
Lock at Pedro Miguel			1.037
Total			9.886
Meetings in transit			.95
Meetings at locks			.36
Total time			11.196

The totals exclusive of time consumed in passing the terminal lock is:

Two lock canal	8.452 hours
62.5 four lock	8.893 hours
85 six lock	11.196 hours

When the time of passing the terminal locks is included, the total works out as follows:

Two lock	10.586 hours
Four lock	11.027 hours
Six lock	12.982 hours
Sea level	12.395 hours

That is to say, it will take two hours and twenty-three minutes longer for ships to pass through the lock flight canal than through one with but two locks. A ship can pass through a four-lock canal in two hours less than through that of the staircase. The two and four lock waterways can be easily traversed in daylight; the sea level and the 85-ft. canals cannot be traversed in daylight.

Comparative Alignments.—The following summary gives the comparative alignments of the four lock canal and that of the latest 85-ft. design of December 17, 1906:

	Four Lock.	Six Lock.
Total curvature	530°—0′	595°—40′—0″
Length of curves miles statute	9.5	8.96
Length of tangent miles stutute	38.75	41.16
Total statute miles	48.25	50.12
Degrees of curvature affecting navigation	139°—40′	140°—55′
Length of curvature affecting navigation.	2.62	2.6

There is *no possible advantage therefore, in time* attaching to the six-lock ladder plan. It takes longer to traverse than any other type, besides being attended with far greater hazards.

CHAPTER XXVII.

Proposed Percentage Contract of January, 1907.

These papers, opposing the Percentage Contract proposed and prepared under the direction of the Secretary of War in the closing months of 1906, were written and published in January, 1907. It is to be remembered that a contract for Chinese Labor was also impending. The episodes are therefore historical. Neither award was closed and a new commission and policy were shortly after inaugurated.

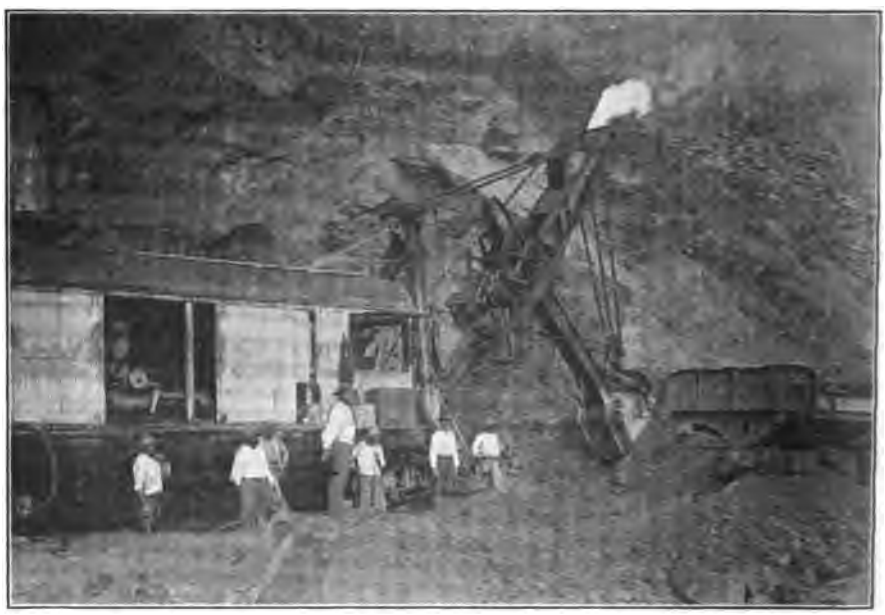
The Contract System, under which bids were asked for the superintendence of Panama Canal Construction, was in March abandoned. The lowest bidder was said to have proved unsatisfactory and the public temper was not favorable to awarding the contract at nearly double his bid. The analysis of the proposal might seem today unnecessary. It is however, reported on important testimony that another invitation is to be made soon to contract the work. The first phase possesses still a vital interest because under the sponsorship and active defense of the Secretary of War it came very near to a deplorable consummation. Since the relationships of such a system remain unchanged the chapters as written are included in this volume:—

The Canal management, failing to get any momentum into construction and being minded to call in a contractor, must provide the percentage for his profit. This percentage cannot be shaved from the Coolies' narrow wage. The labor-contract harpies will have these as their prey, secure in the contract our Government is to give them. It cannot be cut out of the first cost of material. It cannot be made a substitute for the necessary plant. It is an item supplementary to all these, to be deducted out of the residue or failing a residue to be met by further appropriations. This percentage is not a factor in the present rate of expenditure, upon which the deficits were deduced. How much additional must be counted to meet the deficits of "contractor's percentage" on the entire vast construction?

The fundamental warrant for the whole world system of contracting lies in two elements—first, the need for getting work executed; second, the need of getting its responsibilities carried.

The second element is quite as much the basis as the first. Large contractors are supposed to be specialists, en-

trenched in past achievement, fortified in ample backing of capital and buttressed by right bonding houses. They are, inferentially, equipped to take and carry the myriadfold responsibilities, technical and financial, attending a great undertaking. It is by virtue of this lifting of burdens as much as by capacity for execution that the contract system for all orders of work has been evolved. When a great physician is called in and a great physician's fee is given it is paid that he may prescribe and stand under the life and death



STEAM SHOVEL AT EMPIRE.

responsibilities. He is not paid for pouring out medicines; a salaried nurse fills that office.

The type and order of contract in universal acceptance is not an artificial thing imposed from without. It is the evolution of all preceding business history—a growth from within. Under it a definite price is named for a fixed thing, the contractor assumes the chances and delivers the goods.

The American people have been urgent that the Panama

Canal be contracted. They were thus insistent because the word "contract" covered certain definite goals, attained by certain definite means. They wished that an approximately fixed price and a rational price be named for the waterway, and that the Canal be rightly and sufficiently guaranteed to completion at that price. They desired to be free from the anxieties and hazards and in return for their money to be sure of a completed, efficient Canal. A right contract was the normal, universally tested and proved method of securing this end—the old familiar contract type, which the people had invoked and trusted.

Now, instead, a hybrid compact is to be imposed upon the project. Under it no object, which the normal contract guarantees, is secured. The responsibility is not lifted from the Nation; the waterway is not pledged to completion within any definite price or within any covenanted time. All manner of experiments are to be tried by changing groups of engineers, responsible only to a month's salary, and the wide-open treasury is to pay the carnival. Since the Nation stands under the responsibility, audits the misadventures and puts up for all ultimate costs, on the face of it, the distinctive office of a contractor is imposed upon the Government. What is being bargained for is a superintendent of construction—this and this alone. A large contractor, with his experience, his backing, his mechanism of staff, plant, etc., is a high order specialist drawing toll of reward accordingly. The Superintendent of Construction is a salaried man of another grade. At Panama, however, it is proposed to reduce to the rank of superintendent the high ordered contractor, yet to allow him not a salary but a commission.

It was told contractors in the invitation that after they have enlisted five millions or more of capital, have risked life and reputation for years, have assembled a staff and clientele, have accumulated or brought down their followers of sub-contractors, and their men and staff, have labored to determine the engineering and the prices and have struggled with the coolie imposed upon them—after all this, the contract can be annulled and the built-up organization be swept away for $250,000, the outlay of three or four days.

Fundamentally, therefore, this percentage proposal, with no one to guarantee anything, as to whether the canal will be safe or sufficient, or whether, indeed, it shall ever get built at all, sacrifices utterly the just defenses of the people.

But the ill fate by which at Panama there is the highest expenditure for the least return is not reversed by such a contract, and January 12th, 1907, with its receipt of bids, is at hand.

The percentage must promise fair reward if a group of trustworthy contractors shall prefer it before the $500,000,000 worth of good normal contract work in sight in New York State alone. It must be well baited to compensate them for the perils of "three Government engineers and two contractors' engineers" on the committee determining risks and profits. Yes, the percentage must fit the case, and its addition to the deficits should be no unworthy pittance.

What will this percentage be? Are the attendant perquisites so promising that it will be small, as in the Philippine railway instance? Can it be measured and bid by the ordinary standards? Are his five good millions subject to normal jeopardy only? Consider that half his white force will leave, retire or be buried every year, that his proselytizing recruiters must go from the Caribbean Islands to the Andalusian mountains. Silver roll in one hand and quinine elixir in the other, shall he herd them in only to see them go again—this endless procession of the arriving and departing? His premium meantime, except by indulgence of the Government majority upon the cost committee, is becoming wisp of St. Elmo's fire, while his compeers at the North are corralling the sound, healthy business he has generously left behind.

Under all these aspects it is apparent that the percentage at Panama cannot be an habitual "10% on cost." Ordinarily the costs of labor, plant, material, etc., are grouped into one sum and percentage is figured upon it. Here material and supplies are purchased for the contractor—the Commission would not willingly relinquish this prerogative; the plant which the contractor is to use is designed by the Commission; bought by the Commission; supplied by the Commission; repaired by the Commission; renewed by the Commission and directed by the Commission. The two items of materials, etc., and labor are in a wide view of contracting rated at nearly equal. Here the materials are (save by subterfuge) outside his province of percentage, and part only of the labor factor is within it.

The French report reads:

"The contractors are responsible for the excavation of each division and must carry out the plans submitted to

them by the company. The accounts of the contractors' employes are really kept by the Canal Company's agents, and such employes are paid by the paymasters of the company. In other words the contractors are merely the agents of the company to excavate the canal and construct it in its entirety, while the administration, to the smallest detail, is in the hands of the company."

It is to be so now. There were a thousand officials and clerks then to direct the contractors, now the number will be more.

To perform its task the Commission will have a permanent force of clerks, weeding engineers, mechanics, etc.—thousands and thousands of men. Will there be no conflict along labor interests?

There is now one member of the Sanitary Salvation Army to every six workers on the Canal. The Government service and the sanitary service will be the ones preferred. The contractor will be able to keep such only as cannot enter them, or are waiting for the less driven berths. Thousands of men will still be in the employ of the Commission handling materials and supplies, sanitizing, repairing and erecting plant. He will have no profit from this collateral force, but he will get from it his fill of trouble. The call for tact, patience and self-suppression will certainly entitle him to a special harp in heaven, in addition to the Panama Button of Honor. The conventional percentage when labor alone is the basis is 20%. Here traveling and administration will be unusually heavy, and the five millions of capital must earn annual interest and be returned intact. There must be insurance against its loss, the toll of banks, the ever subtracting eights of exchange. The horse leech will cry always, "Give!" "Give!" and 20% on the assigned labor items may be bid.

On a pay roll of $1,500,000 a month this is $300,000, or in, say, eight years, ninety-six months, $28,800,000. Some one may bid less, even one-half or one-quarter, chancing to make it up in other directions. But it is readily seen that the bid of the percentage is no longer here a normal business calculation; it is a matter entirely of bluff or calling the other man's hand. Is the competitor going to put down kings or aces? Will 7.99% take it or must it be shaded to 7.98? It is not the work that the bidder is studying; it is the men. They are playing the game—the game!

Contracting is an honorable science. In its large experience it is in the hands of great and responsible men. But it is degraded in this Panama contract to the level of the bucket shop.

The "form" runs:

"The Commission will retain control of the construction work to be done by the contractor." Is he a contractor?

This is the Secretary's response to the demand that the Panama Canal be contracted. "American ingenuity is not dead," the Chairman's circular comforts us. It might be, so far as it is let rescue the Panama situation or save it against these mounting counts. Have the authorities pointed out the further deficits incident to paying the percentage?

The financial question has another aspect, brought into vivid relief at the moment. The Canal execution is to be contracted. The enterprise is to be tied into one more hard and fast knot. Bids are invited for January 12, 1907. The last revision—the fourth revision published and sent out—went forth December 18, 1906. A vital change in basis was incorporated, and twenty-four days, including Sundays and the year-end holidays, are given as notice for the greatest contract of the ages. American contractors may salaam surely to this display of confidence in their "readiness" at least for the "second stage, that of actual execution."

A year ago the Commission, reproaching the majority of the International Board for their unfamiliarity with the mighty Soo, adopted the designs of the minority. The designs named the lock sites and lifts; the dam sites and heights, the methods of construction, the costs—every basic element for the dash to which Commission, Chief Engineer and War Secretary were already crouched.

With strenuous insistence each feature of this 85-ft. project was urged upon Congress. So hot were its sponsors to its claims that a veto was threatened if it was not put through. In the Senate and in the House, its partisans, taking the word of the official sires, fought for the dams, announced the methods proposed for building them, defended the lock flights here and there, and begged the Conscript Fathers to accept the portentous plan, settled now at last, and not to distract again to incertitudes, or impede the work, awaiting but their word to leap into the homestretch. But these advocates proved too much. The Conscript Fathers remained unconvinced. They gave the rein, however, for

gathering all necessary impetus of execution, in a vote for the general lock type.

The Canal authorities, Secretary, Commission, Chairman and Chief Engineer, clung loyally to their adopted progeny, despite the rebuff—to the plans, means, methods and estimates set forth by the minority. The Chief Engineer wrote that it was much the best plan that has thus far been proposed. This face of "settledness" has been kept to the public stanchly since. As recently as thirty days ago, December, 1906, the very last Isthmian Report, the official authoritative bulletin, reiterates that "all is settled." It runs:

DIPPER DREDGE AT CRISTOBAL. READY FOR TRIAL.

"Since the decision by Congress, in June last, decreeing the construction of a lock canal at an elevation of 85 ft., the Commission has fixed definitely the location on the Atlantic side of three sets of locks and a great dam at Gatun, and on the Pacific side of one set of locks at Pedro Miguel and two sets at La Boca and two dams in the vicinity of La Boca, a large one between Sosa Hill and Corozal, and a smaller one between Sosa Hill and San Juan Hill."

But despite the unswerving front the Canal sponsors were

not entirely happy. Among engineers all over the country were mutterings of great perils in these lock flights and grave risks in inadequate foundations to the massive dams. The distrust was gathering and growing ominous. Then at last came the turn and the call for the contractor and tenders were asked for. In cynical disregard of official announcements Janus at the door of the temple was obliged to turn his inner face. Here was what it disclosed:

"The following plan is descriptive merely and is intended only for the general information of bidders. The quantities of material are only approximate. Even the location and character of structures may be changed. It is, however, expected that approximately exact information will be presented to or collected by the committee of five engineers who under the proposed contract will estimate the reasonable cost and time for completing the construction of the Canal.

"The Gatun Locks are located approximately as shown on Plate VIII. They are to be built in duplicate—that is, there are to be two sets of locks side by side. The lift will be overcome by a flight of three locks of 28 1-3 ft. ordinary lift each, or a flight of two locks 42½ ft. lift each. Neither the details of their construction nor their exact location has yet been definitely fixed. The estimate of quantities in the locks is based on a flight of three having a length of 900 ft. and width of 95 ft. The size of the locks may be increased to 1,000 ft. by 100 ft.

Regulation Works.—"Works for regulating the level of the lake will be located in the hill which lies about midway between the two extremities of the dam. It is possible, however, that the size or location of these regulating works may be changed."

So this omnibus contract invitation showed the engineering still in the air and the Canal design floating about like an untethered balloon. These invitations were issued in November. The bonds and capital were placed at but seven millions on this greatest work of all time. Much was done, under the rose, to interest large contractors. But before the day set the invitations were withdrawn. What had transpired? What befell? The Chairman was under the mortifying necessity of giving out some reason. He chose one and announced that contractors had considered the engineering inadequate and the features of the Canal design too perilous to warrant the enlistment of even the petty bonding

fee and the small capital. The authorities were forced to start anew and issue other invitations, on the basis of unconditional surrender. The government assumed the technical gamble and engaged to support prospective catastrophes at the public expense. These were the facts given out December 8, 1906:

"Meeting the expressed fear of certain contractors that the data on which the present project for a lock canal at Panama are not sufficiently convincing to remove all danger from the enterprise, Chairman Shonts, of the Canal Commission, to-day authorized substantial modifications of the form of contract by which it is intended to complete the waterway. The change will protect the successful contractor from loss should the work meet with disaster through an error in its planning by the government.

The greatest fear expressed thus far by contractors who propose bidding is that the borings accepted by the government engineers as assuring a firm foundation for the Gatun dam are not sufficiently thorough to assure this beyond doubt. The Gatun dam when completed will be the largest in the world, forming a lake 125 square miles in area and saving miles of excavations were a sea-level canal built.

The government rests confidently upon its own research as to the safety of *part* of the project. The answer to the contractors' fear is the government's willingness to bear the cost of disaster caused by such error. Following a conference to-day with Secretary Taft and General Counsel Rogers of the Canal Commission, Mr. Shonts made this statement, changing the date of the opening of bids from December 12 to 12 o'clock of January 12, 1907. The modification insuring the contractors against possible basic error in the canal project he gives thus:

"If it shall be made to appear to the President of the United States that estimates of the Engineering Commitee (composed of three Government and two contracting engineers) are based on physical data so erroneous as to materially affect the estimated costs and time of construction, or that the estimates have become inequitable by an act of God or a public enemy, the President may require the committee to reassemble and modify the original estimates by adding to or taking therefrom additional cost or time fairly attributable to the use of such erroneous data or act of God."

The general plan of the contract is unchanged. It remains on the percentage system, the government to furnish the plant, afford subsistence and quarters to the workmen, govern the canal zone and supervise the work; the contractors are to employ the labor, do the actual work and to receive in payment an agreed percentage of the total cost of the canal.

The original contract called for the successful contracting association to show an unencumbered capital of $5,000,000, and was called upon to deposit a $2,000,000 bond for

faithful and honest performance of the task. This required a stake of $7,000,000. The bond has now been reduced to $2,000,000, which may be a part of the required capital of $5,000,000."

The engineering is not a tassel dangling to the canal shoe. It is the heart and brain and blood of the enterprise. When contractors let its engineering go to protest in the street, they discredited it in its most vital centre. The contract had been made alluring for some, in subtle possibilities. Fundamentally tyrannous and unjust to the contractor, and on the surface holding him in a vise, it left him by winning over one man on the commitee of estimates, the chance for the inside track on costs. These could be made anything. The Treasury was wide open. Here surely was a tempting sop were one a Cerberus. The mess privilege was set in such guise, that by the intervention of a third party, Cerberus could clean up millions—a second luring bait surely. Again in the item of "finishing materials" there was an equivocal opportunity. In half a dozen features, he had the chance of a pirate's lifetime. But the much heralded contract which had been prepared four months previously "after consultation by the chairman, with twenty-five of the most important contracing firms and bankers," was nevertheless withdrawn in defeat.

The contractors had in the meantime investigated, they had searched, some had gone to Panama, and they had no credulity for the engineering. Was ever such branding given to a public undertaking?

Since 1879, engineers, supposedly the first in the world, have been studying the Panama Canal. Commission after Commission continuously have sat upon its problems with a stream of money pouring to them.

As part of the purchase appropriation, $2,000,000 were included for the French maps, studies and reports, that nothing should be lacking to the fullest and highest solution and that our Board, Commission and Secretary might have a quarter of a century's accumulation of thought and experience for guidance at every step. Some of these experts had been since 1895 engaged in the Isthmian assignment. As a final fruitage of collective wisdom and counsel, a scheme is adopted and bids are invited for its execution, and at the first contact of this plan with practical, experienced, executive men, the project is found so hazardous and the engi-

neering so defective that the risks cannot be bonded, and the menaces cannot be banked. Bankers and bondsmen—none will honor the vouching or stand for the expert's experting. The gold in the one scale cannot weigh down the danger of the Brennus sword in the other. The government is forced to itself take the odds and chance the people's money where private capital has refused to stand.

The compulsory withdrawal of these invitations for the first time forced the lid off far enough to make avowals necessary as to the contents below. Not even the weight of the Secretary and the Chairman getting hurriedly back upon it could quite conceal the disquieting truth that there were grave misgivings and alarming uncertainties regarding the very heart features of the Nation's great waterway. The canal chiefs were left in splendid isolation to exorcise as best they might the technical monsters which they had themselves evoked.

Again now they are going to try, if perchance they can drag the engineering balloon down to earth and fasten it. The message gives this Job's comfort:

"The exact locality of the locks at this dam—as at the other dams—is now being determined. In April next, Secretary Taft, with three of the ablest engineers of the country—will visit the isthmus, and the three engineers will make the final and conclusive examinations as to the exact site for each lock."

These are the three engineers primarily responsible for the challenged tiers of locks and the debated Gatun dam. They are going as a court of last appeal to sit as judges upon their own case. And what a case! The country and the prospective contractors will take much conviction of safety in their third final ultimatum!

This, then, in epitome, is what befell and compelled the withdrawal of the first and the issue of the last invitations to an omnibus contract. Now bids are to be opened January 12. We consider them.

There is a very old axiom among contractors—"the specifications and the plans as full and precise as possible, the contract as short as possible." There are two arts involved—the art of the engineer in preparing and presenting a contract and its specifications, and the art of the contractor in bidding for and executing it. On the Panama project, great and vital as it is, the engineers are, as shown, after

three years utterly unready either to prepare or to present their work. They openly announce so, and the highest authority confirms their admission.

On the other hand, the contractor has twenty-four days under the new invitations to make all his investigations and preparations.

With the engineers ignorant themselves as to what they shall finally evolve, how is the contractor to know what must be undertaken? Where are the locks to be or the dams? What processes of construction are to be employed? These things were stated very exactly in the plans issued by the minority of the International Board a year ago. These are the only plans vouchsafed, and they are nullified now. There are, therefore, no designs or details whatever to this marvelous contract. Specifications there are none; plans there are none. Yet the plans are the foundations upon which the bidder must determine whether or not he can execute the project at all.

Take for instance, the safety devices to hold a summit level. A year has gone by since the minority guessed that something would turn up to fit this case, and nothing has turned up. The Scientific American tells us that the Canal Triumvirs are oscillating between a gigantic wicket gate, a huge shutter and a prodigious barrel 46 feet in diameter and 110 feet long. The Gatun Hill is too constricted for anything but the extraordinary. The safety-device for the locks is the feature burdened with the integrity of the canal's defense. It is to be adequate for holding back against disaster a lake emptying with a current of thirty miles an hour. One recalls the lesser barrels that have essayed Niagara and have bobbed about in the Whirlpool, and ponders what this other, the whirlpool rapid of the lock-ladder, would do to the Gargantuan Panama barrel!

Is the contractor to come in here to design the canal and such features as its safety devices? The minority, the Commission, the Chief Engineer, the Secretary, none, has been able to discover on any canal in the world the mechanism fitted to the Isthmian situation which they have made. They have all left this most vital element quite unsolved, dedicating $2,000,000 to its needs, and trusting, Micawber-wise, to the unforseen for luck. Is the contractor to be special Providence to these unsettled problems on which the canal fate is hanging? Then is he in a perilous seat indeed.

In a true contract minds meet—the minds of both—the party of the first part knows his want; the party of the second part knows this and also knows how to satisfy it. He understands what he is to execute and decides how he is going to execute it. But at Panama, contractors are to bid on a work they know not what; to be executed according to some design, they know not how; by some method, they know not which; with some plant, they know not the kind; at a price, they know not how great; and they are to complete it in eight years on forfeit of the bond and capital. Shylock was a straight, open negotiator.

One is full of queries. If the contractor wants to employ a certain method or special plant, will the Commission give him free what he wants, or will it restrict his designs and defeat his plans? Will it honor his requisition for major plant or must he take only what it turns over as all-sufficing? Where is the limit? If it does not give him what he wants, how can he be held to the contract? Will the Commission bury the dead and repatriate the invalid?

What are the regular published rates of the Panama Railway? Are they guaranteed against rise? This delectable organization has already raised freight rates upon a supply house after pledging a certain price. It is noted that the Commission undertakes to supply free water. It does not guarantee the potability or purity of the water. Suppose an epidemic of typhoid or cholera traceable to the water breaks up the contractor's labor organization, will he get damages?

Suppose there be a riot of malaria and yellow fever because of the inadequacy of the sanitation—has the contractor any recourse? Can he help himself? What is "cost plus the usual handling charges?" The contractor has the mess house privilege if he wants it. If he runs it directly and makes a profit it is charged to his precentage; if a loss, he is recouped. Suppose he makes fifty cents a week a man —a reasonable profit, as any one must allow; 50,000 men give $25,000 a week, or $1,300,000 per annum. This is debited to him for nine years, say $11,700,000. Since he can never complete the 85-foot scheme in the time or for the amount appropriated, is he likely to owe the government all the mess profits for his reward?

But a way is amiably left to him. It is allowed that he pass the mess to a third party who is not subject to debit.

The third party cleans up the profit and shares what he likes of his own.

The government, according to the report, does not purpose to make any money on its mess administration. Does it expect the contractor's third party to work for nothing?

Who next gets the rake-offs of the coolie contract—the contractor who takes it over from the government? No—

CULEBRA DIVISION.

some one else—the labor master and his associates will take their toll of the wage. There are a dozen fortunes on the Pacific coast which had their origin in such labor contracts for the railways. New York is full of padrones fattening on the white foreigners, and full of men keen to batten with them. The very bidders to the Chairman are supplying coolies close by at two cents an hour for what at Panama they ask ten or more. They make money out of two cents, since of this bagatelle precious little finds its way to the knotted pocket of the laborer. Eighty cents a day a man

will be velvet; for 2,500 men working $50,000 a month; for 15,000 Chinese $300,000 a month; for a year $3,600,000; for eight years $28,800,000. For more Chinese, more velvety millions—and real millions of the realm, as many as Colonel Sellers saw in his famous eye-water. It is perhaps unto some alien firm. But none of this for the canal contractor. The government has announced its purpose to contract for Chinese labor itself. It has received bids—and the contract is ready to sign. Yet the canal contractor must take over this despised business. It is the deplorable system and memory of old California and Oregon days, of later Madagascar and South African days, of the Kanaka slavery days of the South Seas, of the Congo days, of the Fellaheen corvée days.

America does not need these. There are better ways and better days for the Panama canal.

COSTS.

Contractors have waited for Panama—waited long. The Secretary of War urged the Senate Committee to grant the canal to a period of experiment and let the question of specific detail as to contracts wait on the Commission's search for unit costs. Since 1880 there has been an almost unbroken testing and proving of unit costs. Our government has dedicated three years to this expressed end. The work, as he requested, was left again to the probing and weighing, and at last the Commission itself with his support invites a contract. The Secretary, therefore doubtless knows prices now at last after a quarter of a century. He is ready with the committee of three government engineers to estimate for the execution.

Upon the signature of the compact the contractor's very first premise which he must know beyond peradventure, since his whole capital and bond and percentage are staked in it, is the actual and real cost for each element of construction. The authorities are prepared, then to give this, and can estimate, on, say, the central feature of their 85-foot project —that stupendous monstrosity, the Gatun Dam. They have defined intimately the process to be employed; it was to be built hydraulicly with dredges. This great dam being the second most crucial feature of their scheme, they would, we infer, naturally be exact in insuring its successful construction. They have given precise details of how they intend to build it, and whence the material is to come. This

information is specified not alone in the Board report, it is corroborated minutely in the Senate testimony, and it is confirmed in supporting speeches in both the Senate and the House. So there is no mystery or uncertainty or equivocation about it. The mammoth dam is to be constructed, as to its toes, of rock brought down from Culebra; as to its interior from earth and indurated clay taken between Mindi and Gatun and silt taken from Limon Bay. The material is to be dug and lifted by water machines to "50 feet certainly and 80 feet probably." Now, nowhere in the whole world has this feat yet been achieved. Any existing hydraulic dredge (and there have been built powerful ones) might as well try to pump to Mars. Piping to the distance planned and then lifting to these great heights by relays, is an experiment purely, which shall have its first trial here. How, then, does the Secretary or the Commission know anything whatever of unit costs for the very first feature of their chosen waterway? And what, pray, will the cost committee know? It is to be built by a process which, owing to mechanical limitations, cannot carry the materials directly to its 50 or 80-foot levels, and it involves a plant to cost millions.

"Control of the engineering and construction work is retained by the Commission," the contract reads. Here, straightway, therefore, the contractor is put up against the great Gatun Dam. An impracticable method is provided for him and he is to have experimental plant to achieve the assigned duty. The unit costs in the nature of things must be the merest guesses. This is what the contractor, with his capital, bond and percentages at stake, meets at the door.

What then must follow when the hydraulic machines for the Gatun Dam are two years hence, say, delivered and the limits of mechanism are tested and proved and the assumed unit costs mount up? Where stands the contractor? Does he get any gain out of fiascos? Is he mulcted instead for the extended time and the squandered millions involved in beginning anew, as begin they must in another way? Then, in bringing down the stupendous yardage from the Culebra, —seven thousand continuous miles of twenty-yard cars,—and lifting and placing and puddling it into the heart of the dam, the unit costs of building under the dry method become very different from the abandoned hydraulic process, cheap where it is applicable. Is the contractor fined further,

as a result of changed unit costs? What becomes of his minor plant? What befalls the government's major plant? The contractor will indeed be a convenient buffer for this engineering of the Isthmian waterway.

Then the other prices; how accurately have the Commission estimated them in the past? These are the contractor's only gauge as to how his fortunes must fluctuate in the future under their control. How nearly have they hit, say, the cost of digging with hydraulic dredges, which they propose to use in the indurated clay-rock? It cannot be dug at all that way.

This is the material upon whose rock equivalence the Commission is trusting to build the foundation of the massive locks at Gatun. It is the stuff specimens of which Senator Knox passed around to convince his fellow legislators that it was indisputable rock, when the type vote was concerned.

Mr. Stearns also testified: "As one handled it and looks at it they would call it rock, and that is what it is, a fine-grained rock. I found by taking the knife that I could cut it. It looks something like a fine-grained whetstone, only it is softer than the whetstone that you use."

Senator Knox: "I tried the other day with a knife because it looked exactly like soapstone. I got that impression when I picked it up."

Mr. Stearns: "For any such pressures as come here that is just as good as the hardest rock that you ever saw."

Hydraulic dredges, with cutters, cannot excavate this Mindi clay-rock at any price warranting the consideration of their use. Much of the material will have to be drilled and blasted, or Lobnitized, and the ingenuous proposition of the Commission to dredge the refractory clay-rock by means of a suction dredge with cutters and put it into barges is, to one with first hand experience in building and operating, simply preposterous.

And the expense of taking Culebra material to the old French dumps? The last report allows that this cost is 35½ per cent more in 1906 than even in 1905. The first Chief Engineer gladdened the hearts of all with announcements that his steam shovel artillery had blown prices of excavation to less than "fifty cents per cubic yard." His successor was driven to recall the good cheer, and deplore that the rainy season compelled another story.

One thing, however, is known of prices. Steamers like the Habana and Mexico, when seven years old, exceed in value their original cost, and the principles of amortization do not stand between friends. Where does the contractor come in, then, when "engineering" proves defective, or when by changes it upsets his well-ordered program? Here is a wasps' nest surely. The damage bills entered after the French changes of design will give luminous heralds, and our engineering is in chaos yet.

Next, the Commission hands over to the contractor its shovel plant. The men operating these machines were picked from the labor organization whose numbers embrace practically all the skilled operatives in the United States. They are competent and faithful, and are paid nearly 100 per cent more than men at home. It is reasonable, therefore, to believe that the force has done its best, and that the output for each machine is close upon all that can be expected during the rainy season.

Now, because the Commission has indulged itself in plants of certain types, these are to be loaded upon the contractor. No new methods are devised, no better system proposed. The propostion is only more units of the same kind to operate under the same conditions at the same cost and more men to run them, if such can be had. Indeed, lest another system should be introduced and labor be superseded, it is expressly stipulated that no man on the gold roll now engaged by the Commission shall be relieved or dismissed without the express permission of the Chief Engineer. It is asserted that the contractor's organization is sought, but the Commission force, save those required for its work, are all saddled on the contractor, and he must take over the Chinese also to the privileged quota of 15,000, and any and all other contingents for which the Commission may have arranged. He must either employ another vast staff, thus compounding the gold rolls, or he must take and supplement this force which they have seemingly failed effectively to organize since they call on him.

By labor compulsions and the enforced use of the plants which the Commission possesses and is to supply, the contractor is so bound and nailed that one chance for the canal's salvation is largely forfeited.

A contractor possesses no magic to alter the nature of a tool. Neither can he exorcise the rain and the tremendous

handicaps and impediments which its long season imposes. If, therefore, the self-same system be perpetuated and the identical plant be handed over, what difference in relative records is possible? It is absurd to look for anything but the most meager incidental improvement. Unless the contractor is free to devise his own system, and design and order and control his chosen plant, how is he to be accountable for achievements? He is precluded from doing just the things on which his past success has rested. He cannot choose the makers of the mechanisms he must use; these

FRENCH DREDGE WITH BATES ROTARY CUTTER ADDED.

will be designed for him, and let out perhaps to some bidder who may be inexperienced and slow, apparently cheap, but really dear. He must take what is provided. He has no power of requisition or design. Cranes there are reported already which would not take a curve, and locomotives which could not be fired, dredges that will not touch bottom, hoppers that cannot be loaded with the too light silt. The Commission has in hand an ordering now of still other machines for other offices, so it is evident that the dictation of means and methods remains as of old.

The Commission is further to repair the plant. This is a fertile field sowed with dragons' teeth. A vital machine breaks for instance. The contractor notifies this to the Commission. He wants a new one and cannot get it. The repairs proceed with exasperating slowness and inefficiency. The contractor loses thousands with no redress. Such cases will recur not occasionally but continuously. The contractor will remember that the failure of some plant selected and supplied by the old French company to one of its main contracting groups bankrupted it. Two of the six partners died and the other four were ruined—though they were of those who had got out previously the most cubic mass and made the best progress.

If there was any object whatever in calling in contractors it was that other men unshackled of commitments and unhostaged to past mistakes might with free minds and hands devise other ways and means which would cut costs down to some approximation of the estimates. But the saving of the personal face of things and the perpetuation of the existing order are ends to which the waterway and the Treasury are sacrificed.

Contractors have waited for Panama. They have bided their time. It has come in motley, mask and mystery, in face a stranger to the contract world. And this obligarchy has its reserves; it stoops to bargain. The contract form, through the fourth revision, is still officially said to "be tentative;" "it will doubtless have to be changed in some respects before we can come to a satisfactory agreement with responsible contractors—perhaps even after the bids have been received."

The principle of the competitive contract world is that of equality—each and all on the same basis. Public bids should be things precise; the moment they are opened there is born of equal rights a vested right. The first step to exclude prudent and responsible men from bidding is to announce that the invitation and the terms are tentative; the second to intimate that the contract is open to bargain before the date of receiving bids; the third to suggest that bargaining will be in order again after the bids are received; the fourth is to announce that with five million enlisted and with the contractor's own organization brought down and with work successfully established, the contract can be annulled for $250,000; the fifth is to give him a minority vote in every decision whatsoever concerning the entire construction

that he is to execute and which holds in its balance his capital and his reputation; the sixth is to give short notice; the seventh is to put before him indefinite plans and unusual and darksome conditions; the eighth is to know that the parties of the first part are pledging moneys they have not got; the ninth is to recognize that the whole thing will, therefore, have to be put up to Congress; the tenth is that the bidder must assume unknown labor contracts; the eleventh, that he must take on an unknown staff; the twelfth,

ALONG THE CANAL WORKS.

that he must work with a plant whose design he cannot control; the thirteenth, that he can get plant repaired only as permitted; the fourteenth, that, with capital and bond at stake, he is to be at the behest and direction of passing men, he knows not whom, responsible financially to only their small wage; the fifteenth and the fiftieth he does not reach if he is wise. Was a contract really wanted? Was the contract system to be tested or discredited. Will there be let

a contract at all? Are there groups, associations, syndicates, underwriters, trust companies, bankers, who will venture to run the measured gauntlet? What bonding company shall stake its reputation and its capital for the stipulated bonds and the meagre capital of $3,000,000 to carry a payroll of $1,500,000 a month besides other large imperative needs? Will banks compete for this? Will they speculate in such futures?

The contractor world has truly waited for Panama—but not this Panama. Had the three years built them into confidence in the engineering or into trust in even-handed treatment, or into faith in the management to whose alliance they are now bidden, there would have been another story. Had the past borne any fit fruitage; were there any real readiness to contract; were there any definite plans and precise specifications, the awards of January 12 would have been sought by many and welcomed. The defeated bidders would have said hail and farewell to the victors and have turned philosophically, as men do when the searchlights have flashed the election returns, to their duties, and the hopes of other competitions.

Suppose that within the limits of a fair-set price—contractors are never afraid to name prices—under safe engineering and known factors, the Canal construction were entrusted to some of our Marshals of the Guild. Suppose it given to some of the pre-eminent men with great and varied achievements behind them. Would bonding companies protest over a $2,000,000 bond, or banks feel insecure over the $5,000,000? The memory of the millions won by the Kellys, the Phelans and the Slavens, on the brains of Angel, the forty-niner, have affrighted the Secretary of War. So American ingenuity is garroted, or rather the Canal is garroted to save it from American ingenuity, and plant will be designed and furnished by men who have never designed a successful tool or executed an important piece of water-work in all their lives.

Fancy the contractors told what to do and how to do it, by men who announce openly that they do not know what to do or how to do it; badgered by audits—"which shall have control over the books and accounts of the contractor;" dictated to as to every white employe and every salary—"Who under this article shall not be discharged, nor shall their salaries be reduced except for cause, and then only when

their discharge or salary reduction is approved by the Chief Engineer of the Commission." Fancy them driving the coolies of the indenture, or standing at the bar of public opinion as masters of such negro peonage as disgraces some Southern railway camps!

The contract is no contract. It is a speculation for plungers. A committee of three government engineers are pitted continuously against a contractor's committee of two engineers. At stake are the contractor's capital, its interest, his profits and his bond. In dispute, what are the possibilities of an ultimate appeal? How hopeful is it to go to the Court of Claims?

And will there be Engineer Nouailhacs, whom de Lesseps on appeal will reverse, "conciliating the exigencies of the situation" with 10,800,000 francs?

On the one hand, the contract is tyrannous, oppressive and fundamentally unfair to the contractor; on the other, it puts upon collusion and jobbery the premium of unbridled loot. It is surely not credible that this is to be the solution for the Panama Canal.

There is a better way—a safe way, a right way—the plain, old tested way, a definite price and a definite thing and the standard lines of safe procedure—the good, open, saving grace of a real and true Contract.

HOPPER DREDGE STEAMING THROUGH GALVESTON CANAL.

CHAPTER XXVIII.

PROPOSED CONTRACT (CONTINUED). FINANCIAL ASPECTS.

There is something else in the proposition whereunto this government has invited contractors for the Panama Canal. In January, 1907, a legislative limitation exists. Congress has authorized 145 millions. As much of this as is left only can the Commission loose or bind. How much of the unexpended capital is available for "Execution"? How much money can the Commission pledge itself unto vis a vis the contractor—this contractor to whom it engages execution of the whole work? Is there any pitfall here? Is the Secretary of War pledging what he can deliver; or is the Chairman again knowingly hypothecating what he has not got and gambling upon the popularity of the Canal itself to stay the tide of resentment and rally further assistance, as it did in the $17,000,000 emergency appropriations of last winter, to honor his unauthorized drafts?

There is nothing in the invitation and nothing in the Commission Report of 1906, and nothing in public announcements, nothing anywhere hinting an inadequacy of money for building the Panama Canal. The contractor infers that the money is in hand or appropriated for the work, which the Commission is within fifteen days after acceptance to sign and seal into contract. How much money is then applicable to this Canal execution?

Let us examine the books and count the fund available. But the task is not easy. The Isthmian Report, 153 pages long, devotes, for instance, a page to a resumé of the Panama Railroad operations occupying part of this page, with the promotion of a manager. The cost of its shifting, its double-tracking, its "2,500 to 4,000" employes—several hundred to the construction mile—its steam shovels, its Peter and Paul transactions in fuel, ice and storage, its interest charges, its borrowings and lending, its leasings and its contractings, its division of earnings, its arbitraries and pro ratas with pooling lines, none of all this is even touched upon. Its Annual Report is the private document of a private corporation, though government owned! It goes to Congress in this unwonted guise. The Panama Railroad has been the stalking horse of the roundabout purchases of Supplies and Equipment, of the Markel Contract, of the subterraneous

bond issue and of things allied. Its doings and its payings are of millions, but it is of minor concern here. The major one is of the Canal. To the waterway plans and its financial condition scarcely half a dozen lines are vouchsafed in the entire text of the report. But a statement can be dug notwithstanding from its statistics.

The first question for analysis becomes what amount of money legally at disposal has the Commission got to pay for what the contractor may engage to do? It is not for him to rely upon some illusive hope of "ratification of the Contract by Congress." Congress might balk at the sword-swallowing of these unfigured deficits and these unlimited sight drafts upon the Treasury. If the project goes wrong it surely would. The data taken according to the latest report and figured to January 1, 1907, runs thus:

The Spooner act authorized the expenditure of...	$145,000,000
The original estimate of the 85-foot six-lock scheme exclusive of Zone Government and Sanitation was	139,705,200

Since then the commission has made changes or added work which at the unit prices of the Advisory Board figure as follows:

Colon Section	173,250
Mindi-Gatun Section	679,000
Lake Gatun Section	2,354,000
Panama Bay (increase 3,198,000 cubic yards, with 20 per cent rock, 80 per cent soft).....	1,982,760

These supplements bring the total to roundly $145,000,000.

The Commission has by the text of the invitation and the Map of December 17, 1906, reserved the breakwater construction at Limon Bay and Panama to further experiment and debate, so the sum allotted to the Limon Bay Harbor protection is in this computation likewise reserved:

For breakwaters	$ 5,000,000
There has been expended to January 1	40,000,000

Including the liabilities on orders unvouchered. These, June 30, were over $5,000,000, and large orders have been made and delivered since, but this item is taken at $5,000,000. (This item was later discovered to total $7,750,000.

This leaves for the construction period of "eight years," including Administration Engineering and Contingencies	$100,000,000

Which allows a yearly average expenditure of $12,500,000, which is half the 1906 rate of annual demand on Congress, (or about one-third the 1907 rate as arranged).

For July, August and September, 1906, half the outgo has been for wages and salaries and half for miscellaneous items—plant, material, supplies, etc. It is abundantly plain in considering the progress of the last three years that along existing lines, and under present methods, management and directors, the 85-foot Canal cannot be finished in eight working years at the existing rate of expenditure. To expedite the completion, the labor force is, the Message announces, to be doubled. This must virtually, as shown in a previous article, double the pay roll. The miscellaneous accounts must likewise be very materially increased, because double forces mean more quarters to be provided and furnished, more hospitals to be supplied, more addenda of all kinds, as well as more tools, implements and service requirements and much costly plant (as the article on Preparedness set forth) remains yet to be provided. If one were to represent all this in but a 25 per cent addition to the $800,000 miscellanies now expended every month (which will certainly be allowed to be a charitable minimum), the monthly toll on the Treasury would look like this:

Wages and Salaries	$1,500,000
Contractor's percentage	150,000
Commission and Contractor's Miscellanies, material, supplies, etc., etc.	1,000,000
Total	$2,650,000

After the Canal is dug and the locks are made ready, the whole Canal has still to be equipped with things omitted from the original estimate. There are buoys, dispatch stations, light houses, lights, ranges and other indispensable provisions. But omitting all these and taking only $2,650,000 a month and adopting as multiplier only the hypothetical eight years or ninety-six months, the requirements of this pace under the 85-ft. plan, run to $254,400,000. There is left of the Spooner authorization $100,000,000 January, 1907, so there is apparent a deficit of $154,400,000.

The deficit, figuring in but the increment of 25,000 men additional to the labor force, was $100,000,000. Here, adding the increment of "Material and Supplies," it has become $154,400,000.

A deficit of $154,400,000, and there is next to be reckoned into further account the Panama Railroad changes and its thirty-five miles of very costly reconstruction upon the canyoned slopes. This will be not the $3,700,000 reckoned by the estimate. Its sum will be more than doubled in the excessive cost of the great embankments or bridges shown on the map of December 17, across the chasms, fiords and rivers tributary to Lake Gatun. But, waiving this fact also and adding but $3,700,000, the deficit has still swelled to the sum of $158,100,000, which is more than ten times what we gave Napoleon for the whole Louisiana Purchase of more than 1,000,000 square miles and control of the Mississippi.

This is one way of looking into the question of the adequacy of the money provided for meeting this profligate of an 85-ft. waterway. The contractor being habituated to revolving matters and investigating them from many sides tries another tack to see if perchance he could get himself safeguarded, and whether, without the approval of the contract by Congress, there might still be gathered enough to take care of "construction."

The 85-ft. estimate, with addenda, has already been reckoned at, roundly, $145,000,000.

There is reserved for administration, engineering and contingencies, per report	$23,284,200
Breakwaters	5,300,000
Total	$28,584,200

This leaves about $117,000,000. There has been expended to January 1, 1907, with the liabilities not vouchered, approximately $40,000,000. There remains for canal purposes $77,000,000.

This, then, is the round sum out of which is to be paid the cost of the items to be accomplished by the Commission and the contractor jointly and separately, as set forth in the invitation to contract. This is the sum which will go before the cost-determining committee of "three Government engineers and two contractor's engineers"—the sum within which the Commission must bring their allotted prices, or report that they cannot construct the canal without further authorization and without further moneys.

Naturally the requirements of the Commission will rank first; it must do its part or the contractor is hamstrung at the outset.

But this $77,000,000 is the amount out of which must come, therefore, as the contract form which has received so much anxious care and so little forethought attests:

Item I. The outlays of the Government in what it undertakes to do collaterally with the contractor and for him.

Item II. The contractor's costs.

Item III. The contractor's percentage profits.

In Item I are embraced:

"All plant"—only part of which is on hand or ordered.

"All raw materials of construction," sand, stone, etc.

"Lock mechanism and safety appliances."

"Cement, explosives, oil, fuel, coal, electricity."

"Quarters, warehouses, offices."

"Telegraph and telephone service."

"Terminal trackage, yards, docks."

"Water, repairs and renewals of plant."

"Shops, supervision, inspection," etc.

Contemplating the quantities and scope of expense embraced in each element of this long list, the query becomes to the contractor, how much from the $77,000,000 can become available for HIS costs and profits? He scans the plant account and knows that at least $10,000,000 worth has yet to be ordered. He pictures the locks at Gatun, Pedro Miguel and Sosa. He begins to count the fleets and trains to carry the cement, the sand, the crushed and cut stone, gravel, steel and lumber, the explosives, the oil, the coal and the thousand requirements of the "eight" all too short years; he thinks of the repairs to steam shovels, growing steadily older as they buck the rock or are extricated from their miry burials; the repairs and renewals of the other machines and the assembling of new plant. He turns to the French records and reads the scroll of the great and little contractors, against whom the French company took the same engagement. He reads the records of the Couvreux and Hersent contract, so joyously abrogated for $240,000, very close to the $250,000 he may receive when the Commission has no further use for him. He follows the trail of the "petit entrepreneurs" and the "grand entrepeneurs." He hails his compatriots in the American Contracting and Dredging Company. There is the account of their dividends, divisions, attachments, claims and arbitrations. There is the history of Artigue, Sonderegger & Co., with their De Reinach commissions and their continuous demands for plant

and more plant and higher and higher prices; of Cutbill, De Longo, Watson and Van Hattum and their ousting. The story of the victim Dutch makes bad reading and their pathetic calls for plant and repairs were hopeless clutchings at reeds. Then there was Jacob, Vignaud, Barbaud, Blanleuil et Cie, the Societe des Travaux Publics et Constructions, Baratoux, Letellier et Cie, and last, the great Buccaneer, Eiffel, builder of the Eiffel Tower.

Each and every contract was in respect to the items assumed by this Commission, the same. Page after page of French history is the record of inadequate plant and unarrived plant, wrong plant, poor plant, defective plant, disappointed and reproachful performance, repair and renewal delays, broken faith, broken hope. All this is noted by the man invited to walk in their footsteps, and yet win out glory and fortune to-day at Panama! What must be figured in here under the items plant and materials? These must take precedence of "execution." Their amount must be deducted from the $77,000,000 before he begins to come in. He recalls that the French Company's actual outlay to fulfill its part under the same type of contract amounted on the average to more than $3,420,000 per annum (58 Rapport). He scrutinizes the American material and supplies and plant items of the last three years. They run to nearly $20,000,000. So now, January 1, 1907, one must conclude that there is over thirteen million dollars' worth of material and supplies "distributed" along the Canal, millions in stock and more a-coming. This is several times the French rate. Are our supplies, too, strung from Cristobal to Corozal, and have we something to match every French relic and ruin in swamp and jungle—for the clinging vine and ubiquitous fig tree to hide? Probably not—that is, not yet.

The contractors equipped themselves to dig the Chicago Drainage Canal for an average of about $100,000 a mile. No Commission designed their plant or bought it for them. They had to pay for it themselves, which is a vastly different business. No building of 21,000,000 cubic yard dams on uninvented machinery then; no guessing of quantities and qualities of one-tenth the distance. The man standing on his own capital manages to get informed on some things at least. This Isthmian Commission is a year and a half young, and the $800,000 to each mile, to be excavated, which they have expended in beginning to get ready is eight times the cost

a mile obtaining on the Chicago Canal, and there are any amount of indispensable things yet to be bought. Well-a-day, we started to see how adequate the $77,000,000 were to care for the Commission's engagements and the contractor's part of construction.

It all leads to one conclusion—there is not enough, not half enough, nor, as things are going, a third enough. The pay roll and even a 10 percentage on it alone, for only eight years, demands, under the present design and system, $158,400,000. When to this one adds the million a month of material and supplies, plant and miscellanies, the total mounts to $254,400,000. So with the new factors of an abnormal contract the deficit figures about 177 millions of dollars.

The case against the inadequacy of the money for the Lock-Flight Project is unassailable. Will the contract be legal, or legal only so far as authority exists? Will this Commission be permitted again to bind the Government to pay moneys known to be far in excess of that stipulated and sanctioned by law? The last time this Chairman incurred obligations for twice the cost of Alaska, and Congress had to pass two emergency appropriations. This time it will involve twenty-five Alaskas, or nine Philippine archipelagoes, or nearly the cost of the Spanish War.

A recent decision of a State Supreme Court is pretty good law and common sense. The gist of the ruling was:

Where officers of the Government are charged with power to award contracts for public works, a contract made at variance with the requirements of ordinary and standard practice and the long established custom of all other departments of the Government is prima facie to be deprecated by the officers themselves, who thereby assume responsibilities not warranted, and by the people they serve because there is a departure from the expected procedure.

Neither the Government nor its subordinate officers can make a binding contract for such work, except in compliance and in harmony with the financial provisions fixed by law. The intention of the law, as it is the intention of the people who make both law and custom, in requiring or granting authority to award contracts to the lowest responsible bidder for such work, is to secure the public improvement at the lowest reasonable and approximately known cost to the taxpayers.

Therefore, the incorporation into the advertisements for bids or into the specifications or contract form for the work upon which such bids are predicated, of illegal, of unauthorized or unusual or undetermined conditions or obligations upon the contractor, compliance with which will necessarily or illegally increase the cost of the work beyond the money provided by law, is not a letting of such contract within the meaning of the law, and will render the contract illegal and void, and only to be made legal by act of legislation and by an appropriation sufficiently large to cover the expenditure involved in the contract. Where such an award is attempted by Government officers, under and pursuant to authority conferred by valid enactment, and there has been want of reasonable care or want of reasonable skill and forethought in the exercise of the power and in consonance large, extralegal and indefinite financial commitments as to public expenditure are made, there is just ground for the summary cancellation of their acts and authority.

This is a billion dollared country, but there are voters to whom a dollar out of the Treasury is a dollar out of the collective pocket and, happily for the Nation, it looms like a cart wheel yet.

This deplorable excess of cost is needless and unwarranted. It all harks back to the pernicious design with its colossal dams and its treacherous lock-flights, and the mistaken system and programme of execution with their stupendous labor force. Because this is our greatest enterprise, it must have great engineering, and nothing simple, normal or natural is considered great. Only the abnormal, the eccentric is notable. Great engineering consists in mountain dams and beetling locks. It lies in experiments—experimental dams, experimental locks, experimental locations, experimental processes of construction. Yet nature has provided at Panama perfect conditions for single, isolated, safe locks; for low, unquestionable dams; for simple, inexpensive methods of execution, for real and lasting sanitation, for right prices. But the dead hand is heavy.

In January, 1907, the foregoing paper was prepared and published. Since then Congress has passed a bill with a clause allowing a contract to be awarded *without limit of cost*—a most extraordinary step of legislation considering the vast sums which must inevitably be involved.

CHAPTER XXIX.

Proposed Contract (Continued). Unit Costs.

It has been pointed out in this series that not nearly enough remains of the fund authorized by the Spooner act to construct the waterway under the 85-ft. lock-flight project. The "Crisis" wrote last November:

"American ingenuity is not dead! the circular comforts us. Alas! the patrimony is gone beyond the power of ingenuity, however willing or gifted, to recall. The talents of experienced contractors, fertile in ways and means, and schooled in putting moneys where they tell and carry from beginning to successful end, are called too late to redeem the dissipations and mistakes. Our national enterprise has been already blundered and squandered to its impoverishment. There is left not nearly enough for any combined devisings of groups of brains to rescue and construct this Canal within the provisions of existing law. Unless Congress steps in with a qûite new authorization the waterway cannot be built."

Before a legal contract can be entered into for construction it must be settled that the authorization will not be exceeded and that the fund will be sufficient.

We wonder if before a jury of plain citizens a plea of ignorance here could lift the burden of responsibility. In view of the amount of money, over 43 million which in February, 1907, have gone and the 3% of the turn-over which has been achieved, the Director of the enterprise has not been able to make up his mind whether or not the appropriation will be exceeded. The decision is to be left to "three Government and two contractors' engineers." This is somewhat of an abdication of the authority of Congress. A quotation was lately made in which the Chief Engineer pointed out that in actual equivalent the wage of the Jamaicans now digging the waterway comes close to $5 a day. Waiving this evidence and the high pay of the gold roll, and rating the cost of all labor, white and black together, at only a dollar a day, and estimating but the 25,000 additional men announced in the message, the wage item becomes for eight years $120,000,000. The Secretary and the Commission plead unfamiliarity with multiplication; they qualify, however, strongly in subtraction.

The 1901 Commission had a year in which to thresh out the cost of the 85-ft. project which they recommended. They estimated it at $144,000,000 and Congress authorized the Ca-

nal construction on this basis. Two other commissions have held continuous sessions since. Their whole occupation is with plans and prices and constructions. The greatness and competence of these expert engineers have been extolled and the Minority, Commission, Chairman and Secretary of War supported their estimate anew to Congress. The 85-ft. Canal was set by them at $139,750,000.

When the work comes really up for contracting, is the authoritative judgment of experts and Commission accepted? Not at all. There must be appointed still another Committee of five to begin the business all over again from the foundation. What was the use, one wonders, of calling an International Board to figure upon the prices of structures and excavations and every detail? What were these statements of cost and time, so solemnly vouched for by Commission, Chairman and Secretary of War, if they were not reliable? If the truth is that it was not known and is not yet known what the 85-ft. scheme of waterway will cost, why commit Congress and the American people?

Since it is extremely important that there be some reasonable basis for figuring what the Panama Canal will probably cost, a brief review is made of unit costs and Canal estimates.

The original estimates of M. de Lesseps's engineers gave as a total of Canal cost, 140 millions. It became soon apparent, however, that the thrifty French people considered this such a very great deal of money that the capital could not be raised. The projectors decided that if the enterprise was to be floated it must be come at in a more circumspect manner. Cash was gotten into the scheme plausibly at first; then when deficits began heaping up, more capital was naturally thrown after it in the endeavor to save the first. Finding he had oversized the French temperament, M. de Lesseps ordered a Commission, assembled by himself and paid by the Company, to make a new calculation of total cost. This technical group cut out "Administration, voyages, interest on capital," etc., and put out a second figure of $102,400,000. Had we similarly a Commission which silently dropped "Sanitation and Zone Government" in order to scale down their apparent price, relying upon a later indulgence for the 10 to 30 millions which these costly incidentals must demand?

The French sum of $102,400,000 specified really the engi-

neer's actual figure for the construction itself. But this revised estimate, with only a pittance for administration added, was then published in such a disguise that the public was led to believe that it represented the true and full estimate for the cost of the completed Canal. It will be recalled that this price was almost trebled when the Company went into bankruptcy with three-fifths of its task unaccomplished.

The Rapport reads here of 1885, "They began by paying these new contractors prices higher than were given the small ones. Their contracts were changed constantly, and always with an increase of price over the preceding bargains. Indemnities were given them under many forms. The result was that the price for excavating a cubic meter of earth or rock from an average of 6.25 francs in the first period of work rose to 13 and to 20 francs in the period of large contracts.

"Contracts were much sought after. La Societe Vignaud gave $125,000 to La Societe des Depots, in which M. Charles de Lesseps was interested. An Anglo-Dutch company paid de Reinach $76,653 for a contract to dig 12 million meters in the Culebra. MM. Artigue Sondregger et Cie were obliged to promise de Reinach a commission of 1.40 francs per meter for an increase of price, which they received."

French history worked out its own Nemesis fast. The records read as early as 1885: "In the first months of this year the need for a new loan had made itself felt imperatively. Could they count on the public, and how inform it that the last $60,000,000 which was to have insured the completion of the Canal was still really only an entry into the game. Here was a problem embarrassing enough."

By May, 1888, M. de Lesseps had played upon public confidence to the breaking point. Nothing could gather back the people's faith. The masses deceived so long were thinking and wondering at last. This was, as always, ominous; and clouds hung heavy and low. A last loan was called which was termed in its extremity "L'emission de l'agonie" —"the issue of agony." But the money would not come. On December 14, 1889, a liquidator was named and the knell was tolled.

The contracts at Panama numbered over a hundred. The first with Couvreux and Hersent, along precisely the lines of this "new" American plan, totaled an overhead price for the finished Canal of $102,400,000. But it was canceled be-

fore its executive stage was begun. It served the purpose of inspiring confidence to the point of floating an important issue of bonds. Our pending contract has its purpose, too. "Couvreux and Hersent were not minded in the least to inaugurate the second, the period of execution." They discreetly retired, being allowed $240,000 as a perquisite. Then came the period of the hundred little contractors. We need not present these "annals of the poor," for they broke ground and much besides, until they were set adrift and the great work was divided among the "grand enterpreneurs"—the great contractors.

It must be borne in mind that the contractors' figures were not inclusive of all costs. The company took to itself precisely those myriad things which under the direction of the Secretary of War this Government proposes also to reserve. All the work of sanitation and policing, of providing the vast plant, the material, supplies, quarters, repairs, renewals, etc., remained to the company as to our Commission. One practical difference only exists. The French contractors had to repay 50% of the first cost of plant at the rate of 10% per year. This was a financial measure to make them as careful of the plant as was possible.

Muster Roll of Unit Costs.—We pass over the estimates of the Congress of 1879, and will put in parallel columns the prices of the Walker Commission of 1901, those of the Advisory Board and Minority and those of the Comitè Technique, the Engineering Committee of the Liquidators in 1889, and see how they all compare. These are the estimates of expert engineers. Then we will tabulate the unit prices of the groups of contractors.

We will give the benefit of clergy to the Guild in this call of the musty muster roll of unit costs.

It is but a year or less ago that the Secretary of War, before the Senate Committee on International Canals, requested that a contract be not yet recommended, but that the Canal construction be entrusted still longer to the Commission in its search for unit costs.

Committee after committee, commission after commission, contractor after contractor, since 1879 have been testing and proving this question of unit prices. Yet to-day the Secretary avows that he cannot at all tell what the Panama Canal will demand of the American treasury.

The table will give some index at least of what work at Panama costs under actual execution.

Certain facts become very apparent from these tables. The French began under Couvreux and Hersent with supposedly fair and sufficient unit prices. They were allowed an overhead sum of 102 millions for actual construction of the very small waterway then planned. They had an inside opportunity, the Rapport tells us during the first two years to learn actual facts of costs, and they discovered that the prices allowed were nowhere nearly enough, so they took their $240,000 and quit. The small contractors came in, and then were sent away after excavating some 17,000,000 cu. yds.

"The various means and methods employed were so diverse upon this extensive work that it could not fail to draw attention. Artigue and Sondregger tried the Butte of Bohio by means of subterranean galleries and vertical shafts; Metivier and Rochet at San Pablo tried quite another system; Thirion at Matachin; Bona Brothers at the confluent of the Chagres and Obispo; Murraccioti at Obispo; Cutbill and De Longo in the Culebra; Jensen and De Petro at Paraiso; Carcenac at Pedro Miguel—all these offered a spectacle curious and meritorious of different methods and means.

The sight of 10,000 workmen animating the works of the Canal; the incessant coming and going of locomotives and trains on the terraces; the noise of the innumerable powder blasts which shake the earth; the sight of the numberless machines which attack by the most diverse methods,—all this might well inspire one and give one a confidence in the success of the work. But when one goes beneath the surface of things one is forced to recognize that the actual organization is still very far from getting out what must be extracted to finish the Canal in the set time."

So the many small men were let out, bounties and forfeits were paid galore and the six big companies were tried next.

And read how the company justifies itself at this stage. Might not the chairman of the Commission be speaking instead?

"It is true that we are not yet much at work on the Canal itself, but the great preparatories have been made, to assure the health and the comfort of the enormous horde of workmen who must be employed. Chalets and barracks for the company's agents have been built in high and healthful sites all along the line. Great hospitals have been erected at Colon and elsewhere. Everywhere the warehouses hold vast stores, so that work once inaugurated no halt will be necessary. These stores are provided in a spirit of liberality to those who shall work at the Canal. People say that the work is delayed because we halt needlessly upon these details, but the care with which we are getting ready for the grand enterprise contributes more than anything else to fortify

every conviction that the Canal will actually get finished. While it is true that the work is little advanced, still we have prepared the ground for future comers."

When the six large companies entered the field the unit prices on much of the work over doubled the figures of the first years, and over doubled those upon which the Canal estimates had been based. This began speedily to work mischief with the funds.

But even with these increased figures, the legitimate profits to the contractors seem to have been by no means large. Exception must be made in the instance of the American Contracting and Dredging Company. Theirs was a case of getting a good initial price on the basis of existing things and then riding into victory on an invention. Angel devised a very successful form of dredge, and by cheapening the cost of work the Americans cleaned up a handsome profit. But aside from this unique instance the legitimate gain of the contractors was not large, considering all they risked and endured in executing the work on the Isthmus.

Upon analysis it will be noticed that a large percentage of their gains came through the constant changes of plans, allowances and incident extras.

The liquidator went all over unit prices au fond. The hope still remained that the Canal could be some way put through, and an estimate for its completion based upon the ultimates of economy was ordered. This finality of shavings and cheapenings gives the Liquidator's column.

It will be noted, however, that of the American Commissions each has cut the prices lower than its predecessor.

The legitimate and irregular gains of the various contracting groups, including the sums which they received in the final adjustment of their claims in the transformation from a sea-level to a lock canal, was carefully computed as follows:

Hersent and Couvreux	$ 240,000
Jacob around	1,500,000
Artigue, Sonderegger et Cie	2,287,476
Baratoux, Letellier et Cie	2,502,676
Société des Travaux Publics	4,144,657
Total	$10,674,809

This was exclusive of the profits of the American Contracting and Dredging Company which the investigators were not able to learn further than that they were greater than the profits of any other. One leading firm, Vignaud,

Barbaud & Blauleuil, were bankrupted. The important groups excavated roundly 50,000,000 cu. yds.

In estimating and comparing the probable costs of the different Canal projects, the commissions have based their computations upon unit prices, which they call identical for each proposed design. The self-same unit prices even were used in 1901 in comparing the total costs of Nicaragua and Panama.

Unit Figures of Former Estimates.—Reliable estimates must go far deeper. The ultimate cost of the Isthmian Canal depends primarily upon two main factors. The first is the project adopted. In this rests the amount, place, character and distribution of the excavations, the relative portions that may be done with land and floating plant, the location and design of the structures, the means and methods of execution, the sanitary conditions, and in general all the physical as distinct from the personal elements. The second main cost determinant is bound up with administration. It includes the personal aspects of the work prescribed, the correctness and efficiency of its execution, together with sanitary and police expenditures.

A schedule of unit figures, identical for each type of design, most of them arbitrary and some since proved untrue from work extended over even a short period of the dry season in the use of steam shovels, has been applied for arriving at estimates. This is in principle a radical and pernicious mistake.

Under the most favorable conditions of management, it has been demonstrated that no two projects will work out at the same unit costs at Panama, and that the variation will be very great. Local conditions created and methods of execution applicable to the different designs and different Canal levels, have everything to do with varying the costs of construction. Hence, by the force of logic, the old comparative system of estimating cannot lead to anything but illogical guesses.

Unit Cost of Excavation.—Besides the volume and classification of excavations there is an equally important cost determinant—the manner in which the work is to be accomplished. The excavation problem is a five-fold one, of labor, of plant, of method, of transportation, of unloading and of distributing. Each of these factors is of the greatest significance in determining canal costs, because each helps fix

the amount for which a cubic yard can be disposed of. It is an almost self-evident proposition that so far as regards labor efficiency in the tropics, the scheme permitting the economical employment of the greatest amount of floating plant is, in this respect, the best and cheapest. If under one plan a certain work is done by a well equipped dredge, floating on an open fresh water lake, with a small crew and men of high grade; if under another there must be employed gangs of Jamaica negroes, or coolies, housed well perhaps, but living as such people always do, then there is bound to be a very great cheapening in the cost of the unit of excavation under the first. Every improvement in sanitary conditions also makes a disproportionately great diminution in the cost of work. Not only is every sick man a unit lost from production: he is a greatly increased expense in hospital accounts. He is a center of infection and defection, loosening discipline and making the securing of labor more difficult. This prime superiority—the four lock, three lake plan, and next in rank the two-lock plan possesses. These enable the largest possible use to be made of floating plant and of such machinery as employs relatively few but high-grade men.

UNIT COSTS AT PANAMA.

Table I.

Work.—	Commission d'Etudes de Liquidateur 1890.	Comite Technique 1898.	Commission 1901.	Advisory Board 1906
Removal per cu. yd. of hard rock ..	....	...	1.15	*$1.15
Rocky Material.....	....	.81	.80	* 1.00
Rocky Material Culebra	1.38 to 1.54	.52 to .81	....	.80
Earth not handled by dredges.....	.81	.52	.45	.40
Dredgable material.....	.40 to .52	.44 to .52	.20	.15 to .25
Rock under water.....	....	....	4.75	2.50
Rock dry blasted and then dredged	....	....	...	1.50
Embankment and back fill.....	....	....	.60	.50
Masonry for locks.....	$10 to $12	7.38	8.00	8.00
Atlantic Maritime.....	.52 to .81	....	....	....
Pacific Maritime Section.....	....	.46½	....	....
Rock in Lock Pits.....	2.30	....	....	1.50
Coral Rock.....	....	....	....	1.50
Indurated clay rock under water...	....	....	....	.70
Average Price—				
Excavation.....	1.06	....	....	....
Masonry.....	11.40	....	....	....

Notes—5 fcs. =$1.00. *Except in Culebra.

Table II.

Contractor's Name.	Location.	Classification.	Price, 1888.
American Contracting & Dredging Company. Contract Nov. 12, 1887.	Sea to Bohio.	Dredging below 14.2. Dredging above 14.2. Clay rock. Average.	$ .223 .559 1.97 .777
Jacob. Contract Dec., 1885.	Port of Colon. K. .06 to 1.2 K. 3.1 to 3.6, etc.	Earth and Coral Extras. Average.	.71 .30 to .60 .848
Jacob. Jan. 22, 1887.	Mindi.	General.	1.655
Artigue & Sondregger. May 30, 1883.	Bohio.	General.	1.205
Artigue & Sondgreger. February 12, 1887.	Bohio.	General.	1.11
Vignaud & Barbaud and Blauleuil.	K. 26.350 K. 34.360	General.	.557
	K. 37.500 K. 40. etc. Average.	General.	1.223 .837
Societe Travaux Publics et Constructions. Jan. 16, 1888.	For cutting canal bed proper and diversions of Chagres & Obispo.	General. exclusive of haul.	1.585
Artigue, Sondregger et Cie. Dec. 21, 1887.	Culebra.	General. Average.	1.21
Artigue, Sondregger et Cie. Jan. 9, 1888.	Culebra.	Dry. General.	1.16
Artigue, Sondregger et Cie.	Culebra.	Dry. General.	1.70
Baratoux, Setillier & Co. Dec. 30, 1887.	K. 62.200 fr. K. 68.100	Dredging. General Average.	.934
	K. 68.100 to K. 74.500	Dredging. General.	.645

Average of all Contracts, General, $1.045; Masonry, $22.15

A second great advantage beyond this personal efficiency is the better facilities which such plant possesses to cope with the physical conditions in the tropics.

Rain gives excavation "in the dry" a serious handicap. Efficiency under such conditions is therefore much less than results achieved "in the dry" in the United States would lead one to infer. There is much costly pumping, sinking of tracks, disorganization and many accidents to put up unit prices. These are best eliminated when as much work as possible is done by dredges, whose natural element is water.

CHAPTER XXX.

SANITATION.

In this discussion and in the "Crisis" issue has been taken with the Canal design and with the programmes of execution. Because of its intimate relation to Canal designs and to their programmes of execution, it is imperative to consider the subject of sanitation.

It has been here maintained that the 85 ft. plan is wrong in technique and in principle. Its massive dams have been shown to be projected upon unsafe foundations and to hold back deep lakes in perpetual menace. Its locks have been shown to match the dams in hazard and in defiance of engineering axioms. The programme of execution has been proved to be a veering unsettled thing of startling costs. Its sanitation in the "Crisis" was arraigned as fundamentally deficient in conception and inadequate in attack.

Physicians and hospitals will always be required at Panama. The first should be the most competent and the last the most perfectly equipped possible. That those in charge at Panama are skilled in doctoring and nursing and in this are doing their utmost is fully conceded. But physicians and hospitals should be as supplements to basic engineering, which alone can deal radically with the sources of infection.

Sanitation is needed not alone by clearing and cleaning, paving and sewering, by medication and disinfection, but, in addition, sanitation by the fundamental agency of a right Canal design. Valuable and indispensable as the other measures are, they touch the surface only. This is the issue whereon the Panama inadequacies are deprecated. To undertake to establish and safeguard health upon the Isthmus and yet conserve the deadly swamps through the entire construction period, and the worst of the swamps forever after, is an order of Canal planning and Canal building so mistaken and fatal that it cannot be too much condemned. The elimination of disease, not the healing of disease, should be the first concern. To get rid of disease sources, to root out malarial causes, to banish the foci of infection—this is the basic remedy. And this is an engineering proposition.

Engineering is the only rational, right or sufficient means for securing the fullest health conditions practicable at Panama. It has been seen that from Mindi to Gatun, the eighty-five foot

design projects its channel through the "Swamp of the Quicksands," when by building the low dike and barrage at Mindi it might have covered this whole section of the Canal with a pure fresh lake. It has everywhere ignored engineering as a sanitary agency during the construction period; it has been quite above and beyond fundamental and precautionary measures. It has considered such superfluous for it has promulgated and maintained that the Isthmus has without them been made fully and permanently healthy.

The sphinx of Isthmian disease has sat for 400 years by the roadside, and her riddle has gone unsolved. At last comes not Œdipus, but Æsculapius. He hunts the winged pest, he disinfects, he nets, he kerosenes the pools, and, lo! "all is changed." The voice of the herald is heard in the land. He repeats in myriad issues what he has been officially told, and what he therefore believes:

"Panama is as sanitary as Illinois."

The triumph would need be great and real, for it is the one prized achievement of the waiting years. Over forty millions are expended or pledged January, 1907; three per cent. of the earth turn-over only has been handled; the utter unpreparedness for the period of execution has been revealed, but America, disappointed, still bears and still supports because one great gain has been proclaimed from Maine to Oregon. It has echoed and re-echoed from the Lakes to the Gulf. "The Isthmus is free of disease! Man, woman and child, we have made their habitation safe; they sicken not, they die not; sanitation has triumphed. All is right at Panama."

Panama's Health Records.—No man having at heart the success of the greatest national undertaking of any people in any era should fail to familiarize himself with its long ancestry before it came to our hands for completion. The Isthmus was one of the very first sections of the new continent to be discovered by Europeans in the sixteenth century. It took on decided importance as the convoy route to the West Coast of South America with its Inca Empire. The treasure ships of old Spain made it chief headquarters for transporting the vast tribute of gold which was wrung on all sides from the helpless natives. The Isthmus was not only one of the portals to our own West Coast, but it was the gateway to the West Coast of Central America, South America, Mexico, the Orient and the islands of the Pacific ocean. The Panama story and its

involved health records, therefore, go back far and are well attested. We have no detailed statistics of the ratio between mortality and population during the struggles of the Spaniards and the natives for 400 devastating years, but we have many continuous tales of the unhealthiness, the dominance of Chagres Fever, and the intermittent visitations of the dreaded Yellow Fever, which came out of the unknown,

A ZONE HOME.

wrought its havoc and departed as mysteriously as it came.

Our modern record begins with the gold rush to California in the fall of '49 and the spring of '50. A continuous stream of men passed over the Isthmus, going partly on foot or muleback, partly in canoes between Chagres town and Panama, until the completion of the railway. The details of the struggles to force this line of rails across the swamps and hills is the recital of one long tragedy. Noth-

ing that the wit of man could do within the limit of money was left undone to conserve the health of those engaged upon the enterprise, according to the best lights of that time, half a century ago. But the mortality among its men was so great through the swamp section that it passed into the legend of a "man buried for each rail laid." The force needed was not large, and Isthmian repute had not traveled far; there was always found some to take the place of those who fell or those who retreated disabled from the service.

How de Lesseps Failed.—With the completion of the railway there opened a new chapter in the Isthmian story. The operating of this marvelous 47 miles of track brought larger means and better opportunities. Then came the day when the great Frenchman, de Lesseps, with the Old World laurels fresh upon him, undertook to head the enterprise which should join the great world oceans. The leaders of his army, which had conquered the African Isthmus, followed their chief to Panama. They brought with them the practical experience and organization which had been evolved in Egypt. The directorate were zealous and energetic men of marked executive and inventive skill.

Realizing the fundamental dependence of Canal construction upon health and life, they did their utmost under the circumstances to promote success.

The physicians sent to Panama were chosen men, graduates from their great medical schools and practiced in their world-famed hospitals. They brought into the work all that the best knowledge could provide against local conditions. They built at Ancon a hospital costing over a million and a quarter, so admirably located and so adequately equipped that we have but restored and refurnished, and installed it anew as our greatest institution. At Colon, at Ancon, at Toboga they builded so wisely and so well that we have only repaired the ravages of twenty years of tropic time. At each centre all across the Zone they had provisions equally effective. These doctors and charity nurses met every phase of the battle of sanitation for life and health with high intelligence and persistence through the long years, with all the art that was then known to men and all the heroism that was known to women. It must be testified by everyone familiar with the facts that whatever else the French may have committed and omitted at the

Isthmus, there were no sins against the health of their men. We are told of the inferiority of the nursing because the nuns lacked the training of our modern professionals. But the matchless unselfishness and genuine heart devotion to their black brothers went far toward compensating the modern margin. The tribute given by all writers, our Americans included, to the even greater humanity with which these saintly women tended the blacks than their own more privileged countrymen makes one of the splendid pages, ransoming much of the sombre in French Panama history.

Isthmus Should Be Redeemed.—We have a modern science which should have gained in light, a mosquito theory which is comprehensive and sufficient certainly unto itself; physicians whose names are synonyms for disease exorcism; trained nurses whose intimacy with every needed detail is unquestioned and is here fully recognized and commended. They have had perfect territorial freedom and unstinted millions to spend. America would, therefore, rightly exact that the Isthmus be truly redeemed to better safety than it had ever known.

The French annals and the statistics of their fight of years are quite complete. The early months of their advent gave a very satisfying record, and no one anticipated that anything else would ever come. Machinery was being assembled, work was started in the healthier heights of the Culebra Hills, the Terminal towns were made tolerable and sanguineness reigned. One important fact must be remembered here. The French had no sovereignty over the strip. Columbian officials, jealous of their prerogatives, made concessions only as they wrung full toll. The bleeding of the Panama Canal Company for securing to these people health conditions in their own territory was deplorable business. The French had little power to compel disinfection and health observances in Colon and Panama. It was not to the interest, either, of the natives that the Canal should get pushed too rapidly to completion, and that the expenditure of all this construction money should cease. It was up-hill work, therefore, sanitizing in former times. At the beginning, however, despite this, the health record was very promising. The swamps had not been entered and the grim spectre of their lurking death did not come to the front to throw any misgivings into the enthusiasm of 1879 and 1880.

Yellow fever is not an abiding disease in this Panama

land. It is the passing visitant, not the dweller by the threshold. It has come and gone at the Isthmus a hundred times since the Spanish leeches wrestled with its death. It drops unheralded down, lingers a while and goes again in the self-same subtle way. It is the "plague" of the American hemisphere, and it is akin to the stalking plague of Asia in the mystery of its ways.

Much can be effected to guard against it. Disinfection and burning the places of its habitation will to a degree combat it, and a certain mosquito must be marked for extermination. Everything of promise should be wisely and fully and continuously done. But here at the outset it must be clearly understood that the great living problem at the Isthmus is not yellow fever. There are long intervals the whole way down through Panama history, when nothing is heard of this disease at all. There were years in the French construction time when it did not figure in the sanitary situation. When it shall come and if it shall come is a speculation purely—a dread additional handicap if it befall; a handicap that may not chance. But still a possibility rendered always more likely and more concernfull to men already weakened by the malarial fevers of the Isthmian swamp and jungle.

It did not raise a threatening front within sight of the French newcomers. Their first months were reassuring. But the type selected was one which like our sea level and our 85-ft. project conserved the swamps. These lay along the low miasmic valleys, where mosquitoes and all other pests breed. Here the air is hot and humid. The exhalations are heavy with poison and with fever. It was in these morasses that Totten's railroad force fell in such ratio of deaths that the grim legend of a man to a rail was founded. It was in the digging with these swamps preserved that the French forces began to reel and stagger back before the sea-level task they had undertaken. The latest sea-level keeps them still. The 85-ft. project, it was shown, keeps them always from Colon to Gatun and all the rest during the construction period. The "Swamp of Quicksands," the "Swamps of Death," these were one, and they wrote their names in the crosses and the mounds filling the silent cities of the whole dark route.

The Isthmian foe is this abiding Malarial Fever, the fever born of the jungle, the fever nurtured and cradled un-

endingly in the swamps. In the general enthusiasm of these, our early Canal days, we are filled with the same stimulating good cheer, and it is doubtless well. One must have childhood before manhood, and it is written "sufficient unto the day is the evil thereof." But children are saved sometimes if they can learn to anchor their enthusiasm to that enduring thing—truth. Not much longer can our slow crawling Panama Canal linger. Soon must it come forth and battle where the many before have battled, and measure up then its mosquito safety, its disinfecting safety, its petroleum safety and its netting safety. Its sanitation shall be weighed in the balance of its own official records. Thus shall we learn what is the way of salvation at this Isthmus, doctoring without canal enginering or doctoring with canal engineering. There may not be on this, the real fighting line, a dashing charge against Yellow Fever whose proud "stamping out" has had such trumpet heralding. But there will be the slow, steady, changeless, inglorious fight against the insidious, invisible presences which slowly kill or at best leave men unequal to ever again living and working at their old standards. It is not death which gauges this enemy. The proportion of deaths is large, but it is insignificant compared with the larger roll. It is the undermining, the treacherous sapping, the broken, unfit survivals. It is the long, endless procession borne to the hospitals; it is the ratio of men leaving the scenes of their undoing. Of all this the death rate is but a partial index.

The opinion prevails generally that men grow acclimated to Chagres Fever. But the early records are very explicit in discouraging the re-engagement of any man who has once had a severe attack:

"The Railroad Company (in 1856) are so far conscious of the debility engendered by a residence on the Isthmus that they refuse to employ those laborers, who, having gone to a more healthful climate, return to seek employment. It is found such are unprofitable servants and yield at once to the enervating and sickening climate. The enterprise requires all the vigor of unweakened sinews and of pure, wholesome blood."

The French who came over were picked men. There were sent the ambitious, the aspiring, the courageous. These came to be leaders and directors; to be commanders of the

army, brains of the enterprise. The intelligence and wholesome habits, the white bodies, the vigor of youth, all were in their favor for endurance and survival. But seven thou-

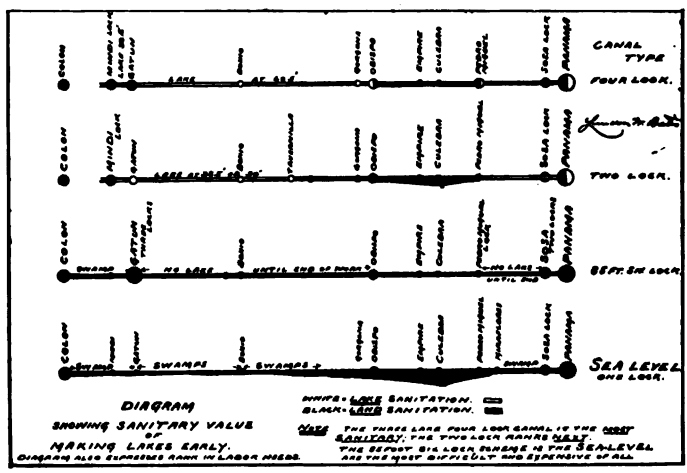


DIAGRAM SHOWING SANITARY VALUE OF EARLY CONSTRUCTION OF LAKES.

sand of these chosen ones went not back from Panama. They sleep to-day where they fell at the perilous post of duty.

The Chagres Fever swept through the camps of the negro diggers, too, and decimated the forces. When it entered into possession of a man it sometimes killed, but oftener it left him unfit to rise again to his level of brain and body. One sees the cemeteries. But he sees not the vaster army that left the Isthmus shattered and ruined for service. Two years were counted as the interval in which the whole labor personnel changed. This is the Isthmian story.

Against its background next the Americans appear—the Americans, like Alexander, panting for more worlds to conquer. They come with a new cult, a fresh, young, alluring cult. Their faith is strong, and their challenge is flung into the face of four centuries with such robust defiance that we rise and cheer for the very triumph-lust in our veins. There is a new creed and a new charter, the cult that a narrow way through the trackless jungle and the reeking swamps with the ends thereof at Colon and Panama can be made so bare, so clean, so sweet,

so free of creeping or winged pest that man may come and go with immunity past the buried city on Monkey Hill. Nature smiles at this Pyrrhic victory proclaimed from the hilltops, with the morasses unpierced and unattempted. But Alexander is triumphant and Hercules was undismayed. The Augean labor of sanitizing at the cost of millions has been undertaken and, it is said, has succeeded. The old order has gone, the new has been established. Salubrity dwells forever at Panama. Yellow fever is stamped out; the winged messengers of malarial fever have been exterminated, and Panama is so sanitary and safe that only sophisticators like the ex-Chairman could resist its seductive charms. True the forests of Peru and the Dutch Islands are still ransacked for the alkaloid diet of the Canal army and its camp followers; true it takes the three daily doses of quinine for every man, woman and child in the Zone. "But what of that," quoth he, "it was a famous victory."

Most Valuable Asset Disdained.—In sanitation, as in all Isthmian matters besides, we are but following the path of youth, the trail of the headstrong, aggressive child, that will learn in no way save the bitter way of experience. The French learned in the same school. When in 1903 our Government took over the enterprise of the Panama Canal it was with all its proverbial enthusiasm. Our self-confidence was boundless. We would exhibit to the world how competent American business methods would put the waterway through. We had a subtle disdain for our predecessors—the impractical French! And we tinctured it with pity, the visionnaires! So we bought all their properties—channel, right of way, railroad, charts, machines, scrap heaps—and smiled, for we believed we had driven a Yankee bargain. One thing was overlooked, and the French with generosity threw it in. It had cost them six times what we were giving for their whole investment—six times the money and their nation's hope. Yet truly for us it was, of all, the most valuable asset—their experience. Had we bought it at a high price it might have been prized and have been let yield us its precious saving service. But it, too, has been disdained, and in blind obliviousness we head the old fateful way. But we do not see the pit, and we insist angrily that none is there. American science has blotted out the twin plagues; malaria has almost vanished, they tell us. The cure cost infinite labor and many millions; but what matters it? The Isthmus

is said to be as salubrious as Illinois or Long Island—all is well at Panama.

Wage at Panama is very high, vastly higher than in the Ocean Islands, much higher than ever under the French. Housing has been provided from unstinting and unquestioning funds. Food of a better order has been pressed upon, thrust upon, our

NATIVE QUARTERS.

black contingent. Wives have been imported and recreations provided. Everything has been done to make their lives one glad sweet song. They came at our beginning in shoals, eager for the high wage and the easy unhastening Government work. But time passed and the labor problem came looming to the fore. Recruiters were out drumming all the hives of settlements, seeking men for Panama, but the "recruiting here will soon have virtually ceased," writes the Report of 1906.

The black is very poor. To him at home the larger chance can never come. His pittance does not rise from the cradle to the grave. So he thronged in the beginning, eagerly, trustfully, in the infectious enthusiasm of American zeal for their Canal.

Recruiters are out on every hand. They came singing the Siren Song to Martinique—Martinique of a buried St. Pierre—Martinique of distress and desolation. The black men went and came back to their waste places. The Siren Song was heard in Jamaica. All up and down the islands of the seas, the recruiters hailed Labor and bade it come to this land of ransomed health, this silver land overflowing in good. The poor and the needy hear, but fewer and fewer heed. Why? Why have the recruiters turned their faces to new lands, and a far land where no whisperings have reached—to Spain's Calabrian Mountains and the Neapolitan Bay? Why did the Secretary of War turn to the Coolie? What word went forth from the men at Panama to the men of the islands? What tale did the homecomers tell? It had learned the actualities, it had tested the truth. It knew that whatever might be the facts regarding the whites at Panama, with all the millions of expenditure and the sanitizing and the public proclaimings, the Blacks, the bone and the sinew, the sun and the rain-beat labor of the Canal under the famed physicians and their glittering theories, were sickening and dying at a rate higher than under the unhonored French doctors, and the unpaid mercy sisters of St. Joseph and St. Vincent de Paul.

The Commission and the Secretary of War have started to make us a canal at Panama. In adulation for the builders and for the building, writers have anticipated and discounted the fevered acclamation of the generation that shall hail its glorious completion.

The house at the Isthmus has, it is officially declared, been founded upon one rock—the rock of Sanitation. This also is the firm corner stone which three years of time and millions of money have set "four square to all the winds that blow." It has cleared the way for labor and the waterway is to be realized at the least sacrifice of health and life. The imperative need of preliminary sanitation has been many times reiterated and we more than agree and support. This is indeed the very bed rock of construction. It must be right and sufficient, if we are ever to have a Panama

canal at all. It becomes the very first and, here at the beginning, incomparably the most important issue of all involved in the waterway. Fundamentally, the adopted project and design, the adopted programme of execution, the adopted plant, the adopted labor, all must be reflected in and must themselves reflect most intimately the sanitation.

If three lakes, two lakes, one lake, or no lake shall be incorporated concerns directly and au fond the sanitation and the method of attack and execution. Whether submergence shall be first or last is of vital moment. If last, then all dependence for sanitizing must remain with existing measures. If first, then the amount of land area which shall be conserved and the amount which shall be drowned bring quite other aspects. Three-quarters of the land width requiring treatment should be and can quickly be eliminated from the task. Upon the decision here depends further whether land plant or water plant shall predominate as executive mechanism and whether large forces of men or small forces shall be required. Men afloat on large water areas have from *twelve to sixty* times the immunity of men ashore from malarial fever. The cost, the labor contingent, the principle of attack, the predominating tool, the areas of swamp submergence, and health vary, therefore, with each design and each level; and there is nothing so erroneous as to accept the method of the international board and figure the same unit prices and the same health conditions and the same executive plan for all designs and systems.

Real Sanitation Ignored.—In the matter of sanitation the sea level is, of course, far and away the worst. It is a narrow pass unrelieved anywhere by a lake. It runs at its beginning amid all the preserved morasses. In the Culebra section its channel, wherein one vessel must tie up while the next works cautiously past it, lies in a defile at the base of a rock-ribbed gorge over 350 ft. below the crest of the frowning hill. Emerging from the cut, it wends again its pest-environed way amid the marshes. Well might a sea level canal be dreaded. The 85-ft. project has at least incorporated some lake surfaces. On the Pacific end, however, it keeps the swamps through all the indefinite construction time, and those upon the Atlantic end to Gatun are in addition held in perpetuity to sow their pestilence for all coming time.

Engineering as the right basic system of sanitation was

ignored by both these projects and largely for one reason. The Isthmus was declared to be sanitized without any engineering features of canal design. Through the length and breadth of the land has gone forth the echo of official announcement—Panama is as salubrious as the north.

Disillusioning is a thankless, unwelcome task. Where it concerns those whom one fain would honor, he can come to it only in profound sorrow. Of all that has been challenged regarding the Panama Canal nothing is brought forward with so much regret as the facts regarding the inadequacy of the sanitation of the Isthmus. But our foreword said, "By so solemnly and unreservedly as we do pledge the Panama Canal, by so solemnly must we all sèt ourselves tc see that the country gets it." Nothing is so intrinsically the basis of the waterway as health and life at the isthmus, and the truth regarding them must be spoken at whatever cost by those who cherish the enterprise.

We know this isthmus—a hot, moist, tropical lowland, with a nine months' rainy season, dense vegetation, pestilent insects, and native low-class population, poor, ignorant, and disease saturated. It is the prospective focus of the world's trade, on which are concentrated the largest number possible of the adverse conditions which limit human accomplishment and human life. Thus is nature intrenched here.

What the Record Shows.—Men must be alive and in health if they are to work; men must work if they are to achieve this waterway, so fatefully momentous to our national history. To make rightly the initial decision, in this is bound up everything isthmian—technical, financial, executive. The right design must be primarily one which secures at its highest, sanitation.

The important factor of the health situation at the Isthmus is not, as was noted, yellow fever. There were three intervals during the French occupancy when Panama's statistics gave not a case. There were three consecutive years without a case and there were four other years in which but a few sporadic cases were recorded, two of these showing but one each year.

The year after the great bankruptcy and dispersal of most of the army of workmen (1890) there was no yellow fever. The next year there were but seventeen cases, and only two in the next five years. In the 370 years that pre-

ceded, this visitant had come and gone intermittently in its mysterious way. Science has been advancing, and we come to the momentous era in which the relation of a certain mosquito to yellow fever was established. But no one knows yet whence the mosquito originally gets his fateful microbe guests.

The army went to Santiago and in that brief campaign it suffered severely. In the occupation that followed the medical corps accepted the mosquito theory and learned to combat yellow fever. In the sanitation of Havana the engineers and the doctors won a signal victory, for which both deserve the highest praise. To what extent this was due to the engineers and to what extent to the medical corps one cannot undertake to say. The engineers think they did it, and are very exact. The doctors wrote the book which told about it, and the doctors had all the credit. Because they got the laurels they have supported the theory that they need no radical help either at the Isthmus. With the monopoly of honors began the cult which was carried to Panama by the devoted and confident men who were constituted guardians of health to those who were to build the Isthmian Canal.

The health problem here is, it is apparent, fundamentally and permanently the question of malarial or Chagres fever. It is interesting to recall that the "new" mosquito theory was advanced as early as 1846 in relation to malaria. Dr. Weir Mitchell of Philadelphia presented to the profession an essay on the origin of malaria and Lieutenant J. T. Sullivan applies it at length to Panama in his report to the Navy Department in 1882.

There should be a full recognition of the vast area inhabited by and supplying this pest at Panama. The zone is 47 miles long, and the channel has 94 miles of flanks, five to ten miles deep, with jungles and swamps and every kind of natural recess for breeding place.

There have been to January, 1907, three years of the sanitizing cult without large remedial engineering—the minor engineering has been that of water works, sewering, ditching, etc. Three years of genuine theory and genuine practice for man and beast along the route of the canal have pronounced the sanitation self-sufficient and pre-eminently successful. So convincing has been the official presentation of the facts, so

backed has it been by tables of vital statistics that the idea is universal and fixed that the Isthmus is at last conquered, disease is harnessed, and death has been defied.

One summary only is quoted. It comes from a principled weekly, generally very accurate. It is typical of the public conviction:

Fever that Kills.—"To this day Chagres fever is the name of a malignant form of malaria that slowly kills men, or at best leaves them unfit to work with brain or body. It swept

WATER FRONT SCENE.

through the camps of the French canal diggers and decimated the forces. You will still see their graveyards thick among the swamps and on the hillsides along the route. It seems impossible that human skill can have conquered the conditions which for ages made this strip of country one of the worst plague spots on earth. Yet American science has blotted out the twin plagues. There is not now one case of yellow fever in the canal zone. Malaria has almost vanished. The cure cost infinite labor. That veteran surgeon,

Colonel W. C. Gorgas, proved when our troops were in Cuba that malaria and yellow fever are communicated to human beings by the stings of mosquitoes and in no other way. He destroyed all the mosquitoes near our camps in Cuba, and our soldiers ceased to suffer from malaria or yellow fever.

"Colonel Gorgas was sent nearly three years ago to take charge of the health of the zone. Where the plague was thickest he was busiest. His men drained away all the stagnant water, for in it mosquitoes breed. He cut away all the underbrush and weeds within a hundred yards of the camps or working places, because in foliage mosquitoes hide and thrive. He poured petroleum upon undrainable little puddles, upon the water in cart ruts, in cattle tracks and hoof prints, etc., because in these places mosquitoes multiply. As a further precaution every door and window in administration buildings, hotels, boarding houses, or any other house inhabited by human being was guarded by mosquito-proof screens. So that all canal workers are now doubly protected. The pests have been stamped out, and should they by any chance drift in and show themselves anywhere in the zone the screens will keep them out of the houses. Every sanitary inspector is a sleuth who never abandons the trail of the mosquito, and regards this puny little insect as Flying Death, far more to be dreaded than all the jaguars and ocelots and pythons that ever lived in the country.

"On that great day when the monument shall be dedicated to the fame and glory of the men who built the canal let us hope that the name of Colonel Gorgas will be found high upon the list. Without his knowledge, his courage, his unflagging devotion, we could not have built the canal, except at the cost of thousands of lives. To-day the Isthmus is as healthful as Long Island or Illinois.

"The Frenchmen failed because they were unable to do away with the diseases that carried off their men. We shall succeed because we have exterminated the deadly yellow fever and malaria.

"Up to date the work of the American forces has been largely preparatory. The 'make-the-dirt-fly' policy with which we began two years ago has given way to a safe and sane plan. 'First we made the Isthmus fit to live in.'"

Nightmare of the Past.—The report of Governor Magoon, for 1906, page 29, reads:

"The Anopheles Brigade has cleared and keeps clear some 2,000,000 sq. yds. of vegetation (about 460 acres) on the Canal Zone. When it is remembered that the vegetation on the isthmus during the rainy season will grow three to six feet in a month the difficulty of this task can be realized. In addition to this the brigade has covered the zone with a network of ditches, for the drainage of swampy ground in order to assist the rapid flow of rain into the natural water courses. Some of these drainage ditches are lined with stones, and the more permanent drains are concreted."

Table 20 of the Sanitary Report shows that the brigade cleared 460 acres some ten times in a year.

It is self evident that everything has been done at the Isthmus which this system admits. It has been done with the highest intelligence and devotion. The reports, the writings, and the speeches of the chief sanitary officer, of the chairman of the commission, of the governor of the Zone, and hundreds of journals, all basing their declarations upon the official statistics supplied to them, demonstrate the universality of the belief that the Isthmus has been sanitized, and that the methods now pursued are successful and adequate. Recruiting agents of the commission have gone all over the United States, into all the islands of the West Indies, into Spain and Italy, and the word has been passed that the old order has gone forever; the Isthmus is now safe.

The ex-chairman, speaking at Kansas City and detailing the expenditure of the millions, said:

"The Isthmus is to-day as safe a place to visit as most other parts of the world, and much safer than many parts of the United States, so far as danger from disease is concerned. Observance of sanitary laws and regulations is compulsory and is rigidly enforced. We have a hospital system which is surpassed by none in the world."

In view of all the foregoing it is surely fair to conclude that this order of sanitizing under the peculiarly favorable conditions of preliminary canal work only, has had a full chance to test itself for Panama.

The approval has culminated in a message which in praise sets forth that the first great problem upon which the solution of the rest depends is solved—the problem of sanitation. The French story is the nightmare of the buried past. The results under the new regime are "astounding." The

Isthmus has been redeemed. Executives will walk in the way "prepared" for them and carry the enterprise through unwaveringly to its great consummation. In corroboration of this pronouncement and in verification of this faith, the vital statistics under American control are incorporated into the message of December, 17, 1906.

It has been before the people six weeks. Not one word has been uttered, not one line has been written in analysis of the report prepared by the chief sanitary officer and sent to the President of the United States.

This sanitary official was intrusted with the most responsible duty that has been imposed upon a man in this generation. He had before him and all about him the testimonials of French struggles and French defeat. He knew what sickness and death meant to this Panama Canal and how sickness and death had wrought havoc here through all its length of years. He owed to the waterway the full chance of life.

Because they are the vital basis of this exposition we quote the tables of the message December 17, 1906.

"**General Statistics.**—The following table shows the population, number of employes, deaths, and death rates. (The population of the cities of Panama, Colon, and Christobal, and the Canal Zone is estimated from the results of a recent census. These figures include employes and civil population. The deaths credited to the Canal Zone include those of employes who died in the territorial limits of the zone.)

Table Showing Population, Deaths and Death Rate.

	Population.	Deaths.	Death Rate.
January, 1906.			
Employes of the Canal Commission and Panama Railroad Company	22,000	74	40.36
Panama, Colon and Zone	46,249	178	46.18
February, 1906.			
Employes of the Canal Commission and Panama Railroad Company	23,135	56	20.09
Panama, Colon and Zone	49,951	176	42.24
March, 1906.			
Employes of the Canal Commission and Panama Railroad Company	25,002	78	37.44
Gold employes of the Canal Commission and Panama Railroad Company	4,377	10	27.41
Silver employes of the Canal Commission and Panama Railroad Company	20,625	68	39.61
Panama, Colon and Zone	51,577	183	42.57
April, 1906.			
Employes of the Canal Commission and Panama Railroad Company	27,219	68	30.00
Gold employes of the Canal Commission and Panama Railroad Company	4,918	6	14.64
Silver employes of the Canal Commission and Panama Railroad Company	22,301	62	33.36
Panama, Colon and Canal Zone	53,671	157	34.91

May, 1906.			
Employes of the Canal Commission and Panama Railroad Company	26,136	54	24.79
Gold employes of the Canal Commission and Panama Railroad Company	5,094	5	11.78
Silver employes of the Canal Commission and Panama Railroad Company	21,042	49	27.94
Panama	26,000	114	52.61
Colon and Christobal	13,000	40	36.92
Canal Zone	21,000	109	62.28
June, 1906.			
Employes of the Canal Commission and Panama Railroad Company	28,010	97	41.55
Gold employes of the Canal Commission and Panama Railroad Company	4,975	3	7.23
Silver employes of the Canal Commission and Panama Railroad Company	23,035	94	48.96
Panama	26,199	87	39.84
Colon and Christobal	13,099	83	76.03
Canal Zone	21,161	147	83.36
July, 1906.			
Employes of the Canal Commission and Panama Railroad Company	28,041	151	64.71
Gold employes of the Canal Commission and Panama Railroad Company	5,052	13	30.87
Silver employes of the Canal Commission and Panama Railroad Company	22,989	138	72.03
Panama	26,199	111	50.84
Colon and Christobal	13,578	88	77.77
Canal Zone	35,000	223	76.45
August, 1906.			
Employes of the Canal Commission and Panama Railroad Company	29,555	153	62.12
Gold employes of the Canal Commission and Panama Railroad Company	5,269	8	18.22
Silver employes of the Canal Commission and Panama Railroad Company	24,286	145	71.60
Panama	26,400	122	55.45
Colon and Christobal	14,078	70	60.00
Canal Zone	35,500	214	72.33
September, 1906.			
Employes of the Canal Commission and Panama Railroad Company	28,264	135	57.34
Gold employes of the Canal Commission and Panama Railroad Company	5,603	7	15.00
Silver employes of the Canal Commission and Panama Railroad Company	22,661	128	67.81
Panama	26,500	100	45.28
Colon and Christobal	14,379	70	58.33
Canal Zone	36,079	180	60.00
Total population (Panama, Canal Zone and Colon)	76,959	350	54.54
October, 1906.			
Employes of the Canal Commission and Panama Railroad Company	25,445	99	46.68
Gold employes of the Canal Commission and Panama Railroad Company	5,520	7	15.27
Silver employes of the Canal Commission and Panama Railroad Company	19,925	92	55.20
Panama	26,700	98	44.04
Colon and Christobal	14,710	76	62.04
Canal Zone	36,680	128	41.85
Total population of Panama, Canal Zone and Colon	78,090	302	46.40
Average number of employes for ten months			26,280
Average number of deaths per month			96.5
Annual death rate per thousand			44.03
Average number of gold employes for eight months			5,101
Average number of deaths per month			7.4

Annual death rate per thousand..... 17.41
Average number of silver employes for eight months.....22,108
Average number of deaths per month..... 97
Annual death rate per thousand..... 52.90
Deaths, by color, for total population of the Zone:
White—
Male 315
Female 102
Black—
Male 1,849
"Female..... 686
Chinese—
Male 52
Female 5
Color not known—
Male 2
Sex unknown 1
Total 3,030

In Table I there has been assembled from various tables of the reports of 1906 and vital statistics of the message a summary showing, first, the number of employes as reported by the sanitary board and, second, the mean effective working force reported by the chief engineer.

Table I.

(See page 62, R. 1905.)

Employes.

Number Reported by Sanitary Department and Mean Effective Reported by the Chief Engineer.

	Sanitary report.	Engr. report.	Deaths.	P. R. R.	Deaths.	Total deaths.	Remarks.
1904.							
October	...	...	..	...	..	..	....
November	...	3,500	..	...	..	..	*....
December	...	...	..	...	..	..	....
1905.							
January	...	...	..	...	..	..	....
February	...	...	..	...	..	..	....
March	...	...	..	...	..	..	....
April	...	...	..	...	..	..	....
May	...	...	..	...	..	..	....
June	...	...	..	...	..	..	....
July	...	9,786	..	...	..	..	†....
August	...	11,726	..	...	..	..	....
September	...	13,684	..	...	..	..	....
October	...	13,953	..	...	..	..	....

November	...	13,255	..	...	..	..	....
December	...	12,571	..	...	..	..	....
Main report.....	...	17,000	..	2,500	..	..	‡....
1906.			§(47)				
January 22,000		14,479	*59	...	*6	74	....
February 23,135		15,130	*40	...	*9	56	....
March 25,002		16,849	*57	...	*8	78	....
April 27,219		16,155	*57	...	*8	68	....
May 26,136		16,997	*45	...	9	54	....
June 28,010		16,145	*82	...	8	97	....
July 28,041		...	*159	...	6	151	....
August 29,555		...	*136	...	10	153	....
September 28,264		...	*115	...	8	135	....
October 25,445		...	*86	...	10	99	....
	...	E16,035	883	...	82	965	....
	...	x17,000	..	4,000	..	..	....
Average 26,280		...	..	...	..	..	a44.03

‡P. 54, 1905. †Report 1906, page 114. ‡24.30 DR. §Outside. *Hospital. xNo page 5, R. 1906. aRate message.

Using the number of employes reported by the Sanitary Department, the mortality rate of the employes is given at 4.403%. This is compared with the record of the French, which for nine years averaged 6.325. The gain of the Americans is on this showing announced and all the health laudation takes its warrant. *But the chief sanitary officer did not make his statistics in the two cases on the same basis.* It does not matter on which basis the statistics are figured, but for comparison they must be figured upon some same basis. The French used as divisor the mean effective number. This fact and the percentage also are recorded by Dr. La Croisade, medical director of the Ancon Hospital. They are repeated by him in the Medical News, vol. 80, page 707, 1902. They are corroborated by General Abbott at length in his "Problems of the Panama Canal" (page 85). They are corroborated again in the testimony before the Senate committee, Report No. 783, Part II.—57th Congress, May 31, 1902. The percentage is employed by the sanitary officer himself in his report to the advisory engineers, page 407. The American mean effective number is

set forth by the chief engineer, page 114, Isthmian Report, 1906, and shown also in Table I.

The official testimony of Dr. La Croisade, for many years the French medical director of the Ancon Hospital, is as follows:

Official Health Statistics of the Panama Canal, French Period.

Table II.

Years.	Effective Force Employed.	Percentage of Disease. Diseases of Europe.	Diseases Due to Climate.	Total.
Old company:				
1881.....	928	21.02	42.03	63.04
1882.....	1,910	18.85	47.64	66.49
1883.....	6,287	23.24	42.62	65.86
1884.....	17,615	27.58	36.95	64.57
1885.....	15,215	11.93	49.14	61.97
1886.....	14,935	14.01	43.88	57.89
1887.....	16,217	21.83	39.25	61.07
1888.....	13,725	12.17	40.46	52.63
Mean	10,854	18.83	42.75	62.58
		Percentage of Mortality.		
Years.	Effective Force Employed.	Diseases of Europe.	Diseases Due to Climate.	Total.
Old company:				
1881.....	928	1.94	4.74	6.68
1882.....	1,910	2.21	4.39	6.60
1883.....	6,287	2.20	4.46	6.66
1884.....	17,615	2.58	4.08	6.66
1885.....	15,215	1.73	3.79	5.52
1886.....	14,935	1.67	3.43	5.10
1887.....	16,217	2.22	3.99	6.21
1888.....	13,725	1.81	2.54	4.35
Mean	10,854	3.05	3.92	5.97

Our United States naval attaché, Lieutenant Rogers, who in 1886 reported at length of Panama matters, wrote thus:

"The sanitary state of the Isthmus depends upon the hydrometric condition of the atmosphere, and the more the subject was studied the more it was demonstrated that meteorological phenomenon influenced to a remarkable de-

gree the health of this region. It is best in the dry season, becomes gradually worse as the rainy season advances, and gradually better as the rainy season passes and dry months begin."

The experience to-day in this respect parallels that of the French and that of the pioneer railway builders.

In April, 1886, Armand Rousseau, who made the most just report of any engineer, summarizes the results. It states that during the years 1884 and 1885 the actual mortality among the white employes of the company was 6.4%. The ratio among other workmen was 7.2%. He further observes that this is not especially different from the 7% average rate for the marines in the French colonies, while the sanitary state of the Isthmus had then been greatly ameliorated by the excellent dispositions taken for the housing of the employes and as a result of the experience and precautions learned in the country. Appendix O, pages 407-8-9 of the Report of the Advisory Board of 1906, gives the vital statistics compiled under the direction of the chief sanitary officer at the Isthmus. From his tables are taken the following:

Table III.

Employes of the Panama Canal Companies, 1881 to 1889.

Year.	Number employes.	Deaths.	Per. 1,000.
1881	928	58	59.2
1882	1,910	125	65.4
1883	6,287	423	67.2
1884	17,615	1,232	69.9
1885	15,215	1,096	71.3
1886	14,935	955	64.0
1887	16,217	1,033	63.7
1888	13,725	605	44.2
1889	1,826	91	49.8
Total	88,658	5,618	63.45

Per thousand for the nine years, 63.25—6.32 per 100.

It is here to be noted that the number of employes includes the staff of the contractors, the sanitary brigade, the workmen in the shops and those handling material and supplies, as well as the workmen engaged upon the canal construction and the track work of the company auxiliary thereto. The numbers used in the tables are the *mean executive*

working force for the periods mentioned, not the full number of names upon the pay rolls.

The French then employing the effectives got an average death rate of 6.325%. Our effectives were for the message nearly 10,000 less than our full force. The sanitary officer figures the American ratio, it will be noted, from the message tables, with a divisor taken of the full number of names on the roll, thus getting a rate of 4.34%. If he employed instead the American effectives he would get a ratio of 6.62, *which is higher than the French record* if similarly reckoned, including all their bad years, in one of which yellow fever alone in Panama City claimed 9.67 per thousand, in another 15.61 per thousand, and in a third 14.39 per thousand.

Thus it results that the death rate of the Sanitary Department, with no yellow fever at all, is made to appear better than the French, when up to this writing, February, 1907, it is beyond all question worse.

When it is realized that the Americans at Panama, with work not yet really begun, have for all the employes a mortality higher than the French average, counting all their yellow fever years, the situation is one which needs open presentation rather than beguiling.

The importance of sanitation to the construction of the Panama Canal makes a full cognizance of its chances and its mischances imperative. The enterprise that the nation has undertaken despite certain vauntings is a hard and exacting one and the canal can be built only as its foundations are rightly established. First of these and immeasurably most important is sanitation. If we have already achieved it—well; the way is prepared for the construction. If not, then the sooner this fact is realized the better, that the remedy may be applied in time.

There are certain very meaning figures in the message statistics apparent at a glance when one knows where to find them. It becomes necessary then to present some analytical tables, every figure of which finds its place from the 1906 Annual Report of the Commission or the official record furnished to this message.

TABLE IV.

Population of Zone and Cities of Isthmus.

(All but the census in 1906 is taken from message of December 17, 1906.)

Deaths.	Date.	Isthmus.	Panama.	Colon & Christobal.	Zone.	Remarks.
	1904.				25,000?	
	Oct.					
	Nov.					
	Dec.		Page 409 A. R. (G) 18,000 E			From Nov. 1st to Sept. 30th, 1905, increase in Pop., 15,075. Page 54. R. 1905
	1905.					
	Jan.					
	Feb.					
	Mar.					
P	Apr.					
494	(May)					
	(June)	46,911 E if				
975	(July)	death rate				
P. 88	(Aug.)	is 62.35. Page 87.				
	.....Sept.		Page 407. A. R. Official. G 20,382 death rate 7.1			
	Oct.					
	Nov.....					
	Dec.					
	...1906.	Message.				
	Jan.	46,219				
	Feb.	49,951				
	Mar.	51,577				
	Apr	53,671		500?		Pages 80-81.,
	Census	*54,940	*22,547	*12,275?	*20,127	Census April.
	May	60,000	26,000	13,000	21,000	1906. 3264,
	June	60,459	26,199	13,099	21,161	
	July	*74,777	26,199	13,578	*35,000	
	(422)					
	Aug.	*75,978	26,400	14,078	*35,500	
*3636.	Sept.	*76,979	26,500	14,379	*36,079	
3030.	Oct.	*78,090	26,700	14,710	*36,680	
241.	Nov.					
	Dec.					

E—Estimated from taking official rate per 1,000 and the deaths. This rate 62.35, is evidently too low, as the population was overestimated.
Death rate in Panama May-August, 1905, 7.41%.
500? This is a guess as to undiscovered transients.
*These figures require scrutiny.

Referring to Table IV, it is to be observed that in the spring of 1906 an official census of the Zone and its terminal cities was taken. The results are presented in the Isthmian Report for 1906. To the actual results of enumeration there were added two arbitrary estimates, one of 500 for Colon and another of 2,000 for the Zone. The sum obtained in the actual enumerations gives a total population for the Isthmus of 55,000 as a result of the census.

Ebb and Flow in Population.—Table IV gives also the population for the successive months. From the same sources and the quarantine statistics is completed the movement of population to and from the Isthmus.

Table V.

Population Movement.

1904.	Enter.	Leaving.	Stayed.
October*	1,776	1,104	672
November*	3,904	2,957	947
December*	4,434	3,180	1,254
1905.			
January*	2,588	1,073	1,515
February*	3,132	1,122	2,010
March†	4,097	2,162	1,935
April†	4,905	2,296	2,609
May†	4,262	2,265	1,997
June†	2,629	1,728	901
July†	3,354	2,196	1,158
August†	4,133	2,063	2,070
September†	4,812	1,607	3,205
October†	3,974	2,295	1,679
November*	1,876	1,558	318
December*	2,431	1,828	603
1906.			
January†	5,791	2,385	3,406
February†	6,780	3,078	3,702
March‡	7,289	3,796	3,493
April†	5,987	3,893	2,094
May†	7,361	3,646	3,715
June†	4,407	3,948	459
July†	4,130	2,651	1,479
August†	3,859	2,657	1,202
September†	3,450	2,471	979
Totals	101,361	57,959	

Report 1905.	Arrived.	Departed.
Foreign	31,971	15,370
Local	8,024	5,622
	39,995	20,992
	20,992	
Gain in 1905	19,003	
Report 1906, increase	24,409	
Total gain 1905 and 1906, less the number of deaths of those who came	43,412	

*Not including local coastwise.

†Includes local coastwise.

‡Includes local coastwise. Census taken.

Table V shows the arrivals, the departures and the net gain each month exclusive of deductions for deaths and additions by births. It is easy to see how this census was used as the basis for the figures supplied by the chief sanitary officer to the executive message of December 17—by deducing from the difference between the arrivals and the departures, foreign and coastwise. For instance, in the month of May to get the population for the month of June the net arrivals, 459, in June, are added to the 60,000 taken for the population of the month of May, giving for the month of June 60,459.

Sudden Gain of 14,000.—Similarly, if from the population of the month of August (75,978) there are deducted 1,201, the net arrivals during August, it will give the population set forth in the message for the month of July 74,777. Or, if one adds to 75,978 the net gain for the month of September, 979, the population is gotten for the month of September, 76,958. But the message gives the population for the month of June, 1906, 60,459, and for the month of July 74,777, while the net arrivals at the Isthmus for the month of July are but 1,479. If one obtains the population for the month of July in the fashion employed by the sanitary officer in presenting the population for the other months one will get for the month of July a total of 61,938. Yet the message gives 74,777. This difference was all placed upon the Zone. The Zone suddenly gained a population as shown by the table of the message of 13,389. Yet in August it added but 500, in September 579 and in October 601 by the statistics of arrivals and departures

In May likewise there was an extraordinary jump of 5,051, of whom 3,443 are assigned to Panama City. Since every man, woman and child coming to or leaving the Isthmus is accounted for at strict quarantine, it appears necessary to attempt to construct a true population table, taking the census as a basis and the quarantine records. This table should be quite accurate, except as to births and deaths.

Table VI.

Estimated Actual Population.

In Colon—without guess as to transients	500
In Zone—without guess as to people of bounds	2,213
Total (from May 60,000 — 57,300 base)	2,713

		Excess Arrivals.
January	44,296	.....
February	47,996	3,702
March	51,491	3,493
April	53,585	2,094
May	57,300	3,715
June	57,759	459
July	59,238	1,479
August	60,440	1,202
September	61,419	970
October	62,550	1,131

Average population, 55,607. Deaths, 3,030.

The basis of the above is a census and the net arrivals; no allowance for deaths ad interim is made, which would increase the death rate figure. As the average population is 55,607 and the mortality 3,030, the death rate, with the interim death allowance is 6.58%, not 5.79%, as the population figure given to the message brings forth.

Table VII.

(From Message, Page 23)—Population.

1906.	Panama.	Colon.	Zone.	Total.	Employes.	Deaths.
Jan.	.....	.....	.....	46,249	22,000	252
Feb.	.....	.....	.....	49,951	23,135	232
March	.....	.....	.....	51,577	25,002	261
April	.....	.....	.....	53,671	27,219	225
May	26,000	13,000	21,000	60,000	20,136	263
June	26,199	13,099	21,161	60,459	28,010	317
July	26,199	13,578	35,000	§74,777	28,041	422
Aug.	26,400	14,078	35,500	75,978	29,555	406
Sept.	26,500	14,379	36,079	76,959	28,264	350
Oct.	26,700	14,710	36,680	78,090	25,445	302
	.....	.....	.....	*62,771	.....	†3,030
Average per month				.....		303
Average death rate per month				.....		.4807
Average death rate 12 mos				.....		5.79%
No. deaths first 6 mos				.....		1,550
Population and death rate				53,651		5.78%
No. deaths first 4 mos				.....		970
Population and death rate				50,362		5.76%

Note.—In May population increased by 6,339; in July population increased by 14,318.

§How does Zone increase 13,839 in one month, when number of employes increases but 31? *Average population. †Total deaths.

Turning to Table VII., it is seen that in the month of July, 1906, the chief sanitary officer reports an increase in the number of employes over the month of June of only 31, at the same time that there is registered a jump of nearly 14,000 increase of population. Where did this 14,000 come from? What did they do? Again in Table VII. one notes that in the first four out of six months the mortality rate is 5.76% per annum. In the months of May and June, however, the number of deaths suddenly rose, as it always does in the bad season, as it always did in the French time. Then we find that the population of the Isthmus has been abruptly increased during the month of May by 6,329. Yet in the month of April the net gain of arrivals was 2,094. This jump of the population factor makes the mortality rate for the full six months .5.78%, nearly the same as during the favorable season. In the month of July the deaths largely increase again, and we find another abrupt jump in population. The faster men die the more the population increases. This time the leap is a gain of 14,318, with no corresponding increase in the number of employes, which was only 31, no corresponding increase in the number of inhabitants in Panama, not even a gain there of an individual, and a gain of 479 only in Colon. All the rest were presented to the Zone population. The net addition of arrivals are recorded as in June 459, in July 1,479, in August 1,202, and September 979. Of the over 14,000 only 31 went to work! The jump in the population total from 60,459 in June to 74,777 in July produces a population factor for the ten months from January to October which allows closely the same mortality rate, 5.79%.

Under date of December 28, there was given to the Executive the announcement that while there were 422 deaths in July there were only 241 in November, and the announcement reads:

"Chief Sanitary Officer Gorgas, in a report to the Isthmian Canal Commission on the health condition in the Canal Zone during the month of November, notes a steady decline in the death rate, both among the employes and the outside population."

This is the normal story of the season as a diagram will confirm.

Higher Than Under the French.—Comparing the French and the American record with about the same mean effective forces, the number of deaths in the French force is seen to

be 462, in the American, 674. Or, in other words, the rate from May to October of 1906 is shown by Table VIII. again as over 40% higher than under the French regime.

Table VIII.

(Mortality.)

	French, 1884.	American, 1906.
May	41	54
June	52	90
July	62	165
August	88	146
September	97	123
October	132	96
Totals	472	674

Next there is presented:

TABLE IX.

Zone.

	Population.	Deaths in Limits.	Rate from Message	Deaths in Hospital of Zone. Employes.	Non-em's.	Total.	Died Outside Hospital.	Employes Deaths Colon Hospital.	Total Employes Deaths, Hospital.	Total	
January	.....	...	.....	46	9	55	..	10	65		
February	.....	...	.....	35	6	41	..	14	49		
March	.....	...	.....	50	18	68	..	15	65		Deaths
April	.....	...	.....	52	9	61	..	13	65		Outside
May	21,000	109	62.28	39	20	59	50	15	54		Hospital
June	21,161	147	83.36	58	26	84	63	32	90	965	918=47
July	‡35,000	223	‡76.45	137	25	162	61	28	165		
August	‡35,500	214	‡72.33	123	20	143	71	23	146		
September	‡36,079	180	‡60.00	93	24	117	63	30	123		
October	‡36,680	128	‡41.85	66	22	88	40	30	96		
		*1,369				†865					
Ten months		1,382		699	179	878	504	219	918	965	
Last six months		...1,001	.....	516	137	653	348	158	674		

*This includes employes who died in limits of zone. †Page 27.
‡These population figures and rates are all erroneous and misleading.

Sixty Per Cent of White Force Departs Annually.—On Table IX. is shown the population of the Zone and its relation to mortality. Correcting the palpable errors for the months of July, August, September and October, we can reckon the average population of the Zone at approximately 22,000. The census set it at 20,127 in the spring. The mortality rate in the Zone would become then closely, 9.1%. Testimony apparently goes to show that the white population of the Zone is relatively healthy. If they are relatively healthy, this is well, but how comes it?

The death rate must be contemplated in connection with the fact that nearly 60% of the white force departs annually. Turning to page 125 of the 1906 report one finds the following set forth:

There had been expended in behalf of the white employes:

For quarters	$1,060,636.47
For hospitals	443,548.12
For repairs	26,040.31
For repairs	7,402.08
	$1,537,626.98

In addition to this there have been large expenditures for administration buildings, etc., the welfare of the white man has been admirably looked after. But for the silver or colored employes there is another story. Expenditures for them run as follows:

For quarters	$245,846.86
For repairs	9,018.49
A total of	$254,865.35

According to the message the white population on the rolls numbered 5,101, the colored 22,108, or 4 1-3 times as many. It follows, therefore, that about 26 times as much in quarters has been done to safeguard the life and health of the white employes as for the colored. Since most of the whites work indoors and the colored outside, it may be said that over 50 times as much has been done for one as the other. Because, in addition, there have been outlaid for offices, stores, warehouses, etc., large sums. In these during the hours of work most of the white employes are sheltered from heat and sun and rain, and enjoy every possible convenience. These figures take no account of the very special efforts put forth by the Sanitary Brigade to further protect the areas where the whites are quartered. When everything of this character is counted, it is small wonder that the colored laborers depart, die, lay off sick or make up the perfect stream of admittances to the hospitals. If as much were done for the colored laborer as for the white employe there would be expended on quarters alone for 19,000 men, $5,320,000 instead of $246,000. Double this, or over ten million dollars, would be required for the 25,000 additional force, which the message announces is to be brought to hasten construction. The hospitals will

all have to be enlarged. Even now a hospital bed at Ancon is used by four patients per month. A week is not a long sojourn surely for a man down with Chagres fever.

Evidently much must be contemplated still by the Department of Building and Construction, and much remains for them to do to properly house the colored employes, a large proportion of whose mortality and sickness must be due to the inadequacy of the allotment to their sanitary needs.

Hospital Story.—The preceding papers have regretfully established the facts regarding Panama sanitation. It has been seen that the riddle of this Sphinx has, alas, not been solved, for she still sits by the highway taking larger toll than before. The mortality has been considered, but death, it was pointed out, is not the supreme measure of Isthmian evils.

The hospital statistics are of suggestive interest. They are given in Tables X and XI. During the ten months of 1906 29,308 entered the hospital, of whom 26,571 were employes—that is to say, 89 employes a day were taken from their quarters or their homes, to the hospital. For the fiscal year ending June 30, 33,677 were treated. So that in the first ten months of 1906 the hospital admittance for employes, as counted by the chief sanitary officer, was at the rate of 120% per annum. In these ten months, to maintain an effective working force, including those employed on the Panama Railroad, the rate is over 159% per annum.

"Salubrious" Panama.—The year's hospital record on a 25-mile section of the New York Barge Canal has been less than 1% sick and no deaths. The sick rate at Panama is over 159 times as high as on this work in the United States. Yet Panama is as "salubrious as the north."

It is to be remarked regarding the railway and accidental deaths in the ten months from January to October, 1906, that the number totaled 122. This indicated the lowering of alertness and physical fitness in Isthmian conditions and a lamentable lack of care. On one occasion a superintendent from an observation point on Gold Hill counted 16 wrecks in the Culebra cut. It is a fit subject for the liability companies or contractors to consider.

From Rogers Report 1886 for Panama and Colon Hospitals:

Table X.

Employes in Hospitals.

	French 1883	French 1884	French 1885	French 1886	U. S. Hospital Sick Camp.
January	537	677	947	372	503
February ...	457	700	587	...	472
March	520	802	674	...	491
			440P	...	
April	539	602	C?	...	421
May	510	639	687	...	466
June	499	692	745	...	858
July	539	845	750	...	1,108
August	650	1,027	862	...	1,261
September ..	669	1,055	967	...	1,065
October	755	1,130	872	...	857
		(5,388)			(5,615)
November ..	734	1,122	562	...	799
December ...	649	1,115	431	...	
Employes .	6,267	17,615	15,215	...	14,935

The Americans use the figure of all names on the pay-roll, 26,280. The French the average actually at work.

Table XI—Message Statistics.

Admitted to Hospital, Including Railway Men.

	E & N. E. admitted.	Employes. admitted.	Outsiders.	Sanitary Report— Population.	Employes.	Deaths.
1906.		1,935				
January	2,386	207	244	46,249	22,000	65
		1,691				
February ...	2,127	199	237	49,951	23,135	49
		2,038				
March	2,439	172	229	51,577	25,002	65
		1,392				
April	1,715	146	177	53,671	27,219	65
		1,645				
May	1,998	140	213	60,000	26,136	54
		2,677				
June	3,245	274	294	60,459	28,010	90
		3,729				
July	4,446	314	403	74,777	28,041	165
		3,843				

August	4,580	379 2,844	358	75,978	29,555	146
September ..	3,451	311 2,361	295	76,959	28,264	123
October	2,921	274	286	78,090	25,445	96
Total	29,308	26,571				918 *47 965

Note.—Eighty-nine employes per diem go to the hospital. *Forty-seven employes died outside the hospital.

In the fiscal year ending June 30, 1906, there were treated in the hospitals a total of 33,667.

The total population is taken from the message, Page 23, and is there overstated each month from 2,000 to 14,000, thereby making all deductions as to sick and mortality rates on the part of the sanitary officer erroneous.

Table XII.

Canal Employes. Sick Record.

	Mean Number Employes.	Canal Employes. Hospital Admissions.
July, 1905	9,786	1,070
August	11,726	992
September	13,684	.....
October	13,953	1,639
November	13,255	1,785
December	12,571	2,104
January, 1906	14,479	1,935
February	15,130	1,691
March	16,849	2,038
April	16,155	1,392
May	16,997	1,645
June	16,145	2,677
July	*.....	3,729
August	*.....	3,843
September	*.....	2,844
October	*.....	2,361
Total		31,745

Constantly sick in July, 1,127; in November, 799.

*Not reported, but must be about the same as in June.

On the average 70.5 employes from the Canal force, as distinctive from the railway, went to the hospital every day the past 16 months (prior to January, 1907); and in July and August last nearly 125 per diem. Is this Illinois?

The average number of employes, according to the Sanitary account, was.....26,280
The average population.....55,607

Average population outside employes.....29,327

Out of 26,280 employes there died 965, a rate of 4.403%.

Out of 29,327 outsiders there died 2,065, a rate of 8.44%.

But using the engineer's and the French basis of the mean effective force, the mortality for the employes in 1906 was 6.62 or 50% higher than that given out by the sanitary officer in comparison with the French.

Summary.

The actual death rates as deduced from the vital statistics of the message of December 17 and the report of the commission for 1906 work out:

For the Isthmus 6.58%
For employes, mean effectives..... 6.62%
For outsiders 8.44%
For Panama *4.80%
For Colon and Cristobal 6.18%
For Zone, approximately..... 9.10%
For white employes, 8 months.....†1.74%
For colored employes, Gorgas basis.....†5.29%
For colored employes, French basis.....7.32% to 7.83%

*Probably 5.5%—low because population inflated. †Message. ‡Estimated mean effective from 15,000 to 15,900.

Colored Laborer Neglected.—It is perfectly evident from all the foregoing that the general claim that the American Brigade is doing better than the French, is not founded on fact, but is untrue. The white employe now is better provided for and is apparently healthier than in French days; the colored laborer is the reverse, and for perfectly patent reasons—he is not cared for in any due proportion.

The writer was in the plague and famine districts of India at their worst and the white death rate was that of London, and about the same as is now that of the Isthmian gold roll. But the native was dying at five to ten times the rate. At this Isthmus the colored employe's rate is likewise four or five times as high as the white.

Through the months of this heralding of health there

drifted out to the world a few evidences substantiating what it is herein seen the statistics themselves have recorded. Three only are cited:

Dispatch of August 1, 1906 to the New York Herald:

"This rainy season has been a heavy trial on the canal builders, the railroad and the sanitarians. There has been a riot of malaria, all the departments being hampered with so many men in the hospital. Colon and Cristobal have had the worst of the plague of malaria, and never since the former has been a town has there been such a condition of mud and impassable streets."

"Steamer a Floating Morgue.
Three are Dead and Sixteen Ill With Chagres Fever on the Whitehall. Others in Hospital.

Quarantine Officials Declare Tropical Ship is a menace to Health of all Ports and cannot dock at New Orleans—Only two of the Crew Immune from Malignant fever.

New Orleans, La., Aug. 4, 1906.—The steamer Whitehall, from Colon, was to-day declared a menace to the health of all ports, and orders were given by the State Board of Health to hold her indefinitely at the Mississippi River quarantine station. The Whitehall has one of the worst fever epidemics on shipboard in the records of tropical shipping, having arrived here two days ago with most of the crew ill with Chagres fever. With the death to-day of the steamer's second officer, three of her complement of twenty-one men have already died and sixteen others are in the hospital. Quarantine officers say that when the Whitehall entered the Mississippi River with scarcely enough men to run her, so great was the amount of dirt and swarms of flies on her deck that the nerves of the experienced physicians were shaken as they boarded her. The steamer will not be permitted to come to New Orleans even after the fever is cured."

Malaria Among Marines.—Page 22, Report of Surgeon General of the Navy, 1906. Malaria among the marines of a detachment sent to the Isthmian canal zone in the U. S. S. Columbia.

"A battalion of four companies of marines, of a hundred men each, left Philadelphia, Pa., in the U. S. S. Columbia, May 20, 1906, and on May 29 and June 4 disembarked at Colon, Panama. All were temporarily quartered in houses at Camp Elliott, on high ground, twenty-five miles from Colon. June 23 three companies were transferred to Camp

Reid at Corozal, on low ground, about two miles from Panama. At Camp Reid mosquitoes were very numerous. Each man was provided with a mosquito net and men on guard at night were required to wear head nets. It was impossible, however, to avoid mosquito bites. A dose of nine grains of quinine was given daily to all as a prophylactic. July 2 the three companies at Camp Reid returned to Camp Elliott. July 6 the battalion re-embarked on the Columbia and sailed from Colon. After coaling at Guantanamo they reached Monte Cristi, Santo Domingo, on the 12th and there ninety-eight men and two officers were transferred to the U. S. S. Dixie. From the 6th to the 12th of July the total strength of the battalion was 398 men and officers. Of this number 135, or 34%, had malarial attacks. After the transfer of men to the Dixie had been effected the Columbia was sent to San Juan, P. R., to land the sick, and was there put in quarantine for five days. As the hospital accommodations at San Juan were inadequate to care for the large number of sick, the Department decided, on the recommendation of the medical officer of San Juan Naval Station, to utilize the five days required for quarantine at San Juan in bringing the Columbia to a northern port, and ordered her to proceed without delay to Boston, Mass. The ship reached Boston on July 21, and twenty-eight men and three officers of the marine detachment, infected with malaria, were transferred to the naval hospital Chelsea. From the 13th to the 21st of July the strength of the battalion was 298 officers and men. Of this number 215, or about 72%, had acute malarial paroxysms. It is not unlikely that the whole battalion was infected. With the change to a northern climate and the free administration of quinine to every member of the detachment the percentage of cases rapidly declined to 10.7% on July 21. No fatal cases occurred.

The Negro Cares for Himself.—We quote from Dr. Rixey in Appendix 6 of the Message of December 17th:

He is "of the opinion that here lies Dr. Gorgas's principal work—convince the Commission that their (the negroes') mode of living should be kept under observation and altered at any cost. The preparation of their food in the tropics in filthy vessels, over a few coals in mudholes, and their custom of having in many instances only a single suit of clothes, in which they work during the day and sleep at night, leaves no hope of improvement until some means are provided for

compulsory personal hygiene. How to accomplish this is like teaching the hog to change his beloved hog wallow. Your October report is most interesting. Of the 5,500 whites on the rolls there were only 2 deaths from disease, whereas of the 19,000 negroes 96 deaths, or in a population of negroes a little less than 3½ times that of the whites there were 48 times the number of deaths. This is an enormous difference, and is due to the way the negro cares for himself."

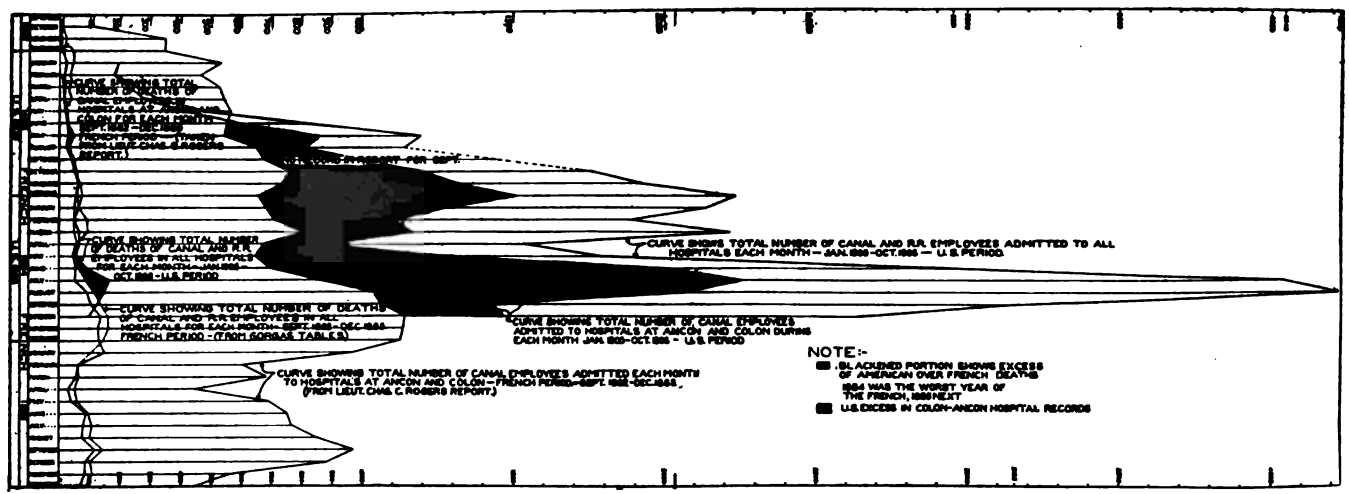
The custom of having only a single suit of clothes! The way the negro cares for himself! Forty-eight times the number of deaths!

A quotation from the speech of the ex-Chairman at Kansas City throws further light:

"In regard to the common laborers from the West Indies, experience has shown that no price for food can be low enough to induce them to eat a sufficient quantity to keep them in good physical condition. We offered them cooked food at 10 cts. per meal, and the uncooked ingredients of the meals at a price reduced by the cost of cooking and service. Both plans resulted unsatisfactorily.

"Beginning with the 15th of the present month we are paying them a fixed wage, including three cooked meals a day. Two important gains are expected from this policy. If their physical condition is improved because of nourishing food, Chief Engineer Stevens believes their efficiency as workers will be increased, and Dr. Gorgas believes their power to withstand disease will be perceptibly magnified."

The Unpaid Fever Cot.—Here are simple men, children in experience, coming from homes far distant. They see among their mates a death rate of 7 to 8% (French basis), a hospital rate of 160%, a departure rate of 50 per cent. The span of time, they know, is very narrow, wherein they may gain. They shall take their way soon to flight, to the unpaid fever cot, or to the grave. Yet they have come thus far, and have ventured all the chances for this margin of opportunity. So eager are they for the silver to have and to hold that "no price of food can be low enough to induce them to eat a sufficient quantity." They do not go foodless for amusement, these men; stomachs are not the exclusive possession of any caste. They sacrifice for something precious their chances of health and survival. It is for the hope of the forthgoing to bear back a larger pittance to the island homes, where their human hearts have their lowly


CURVE SHOWS TOTAL NUMBER OF CANAL AND R.R. EMPLOYEES ADMITTED TO ALL HOSPITALS EACH MONTH — JAN. 1880 - OCT. 1888 — U. S. PERIOD.
CURVE SHOWING TOTAL NUMBER OF DEATHS OF CANAL AND R.R. EMPLOYEES IN ALL HOSPITALS FOR EACH MONTH — JAN. 1880 - OCT. 1888 - U.S. PERIOD
CURVE SHOWING TOTAL NUMBER OF DEATHS OF CANAL AND R.R. EMPLOYEES IN ALL HOSPITALS FOR EACH MONTH — SEPT. 1881 - DEC. 1888 FRENCH PERIOD - (FROM GORGAS TABLES)
CURVE SHOWING TOTAL NUMBER OF CANAL EMPLOYEES ADMITTED TO HOSPITALS AT ANCON AND COLON DURING EACH MONTH JAN. 1880 - OCT. 1888 - U.S. PERIOD
CURVE SHOWING TOTAL NUMBER OF CANAL EMPLOYEES ADMITTED EACH MONTH TO HOSPITALS AT ANCON AND COLON — FRENCH PERIOD — SEPT. 1881 - DEC. 1888. (FROM LIEUT. CHAS. C. ROGERS REPORT.)
NOTE:-
BLACKENED PORTION SHOWS EXCESS OF AMERICAN OVER FRENCH DEATHS
1884 WAS THE WORST YEAR OF THE FRENCH, 1888 NEXT
U.S. EXCESS IN COLON-ANCON HOSPITAL RECORDS

GRAPHIC DIAGRAM SHOWING COMPARATIVE SICK AND MORTALITY RECORDS.

treasures. This is the other side of the "hog in his beloved hog wallow." Is manhood nothing that such poverty and struggle and sacrifice is but ignoble? These trusting men who have come to stand in the southern sun, where we cannot stand; to soak in the drenching rain and build for our great Columbia her world Canal, who lay on its altar their forty-eight lives to our one; have they no claim to a better chance? Have they no right to a fuller survival?

Whatever be their depth of poverty, one fact remains, and this fact is momentous. The horny hand in a last analysis holds the success of the Panama Canal.

The mortality, as was earlier emphasized, is but a small index of the sanitary situation. The story and its meaning are to be gauged in connection with the stream of admissions to the hospital, the constant departures, the laying off, the lassitude, the mental slowness, the coming to the Isthmus with the dry season and the leaving as the wet approaches, the shutting off of the recruiting in the West India Islands, save as a Kingston earthquake may drive them forth for retrievals, the turning to the Coolie and the vast labor reservoir of China, which knows nothing of Panama and whose Legrèes care less.

Better Plans—The Sanitary Brigade have planned, they have worked, to solve the health perplexities of the Isthmus. So intensely have they wished triumph that they have permitted this devotion to ally itself with something different. It would have been far wiser to have acknowledged early that this Panama situation will have need of the fullest and the highest that the science of the physician, and the science of the engineer also, in its most radical provisions can secure. We must have the Panama Canal. This is first, last and altogether. There can never be a change or a wavering in this fixed, final intent. It cannot move the purpose of this country or of those charged with the building of the Isthmian waterway that the health record is worse than that of the French. But the Sanitary Department reports have become the basis of engineering plans and projects, and of every treatment that enters into the construction of the canal.

This sanitizing has cost $6,500,000 to January 1, 1907, including sanitary public works. The former Governor says an area of two million square yards has been kept stripped—about 460 acres, half of Central Park. How different would have been the tale, if, instead of recruiting tens of thousands of laborers

and then struggling heroically to care for them, those in authority had built four small barrages with a few men and machines and had redeemed—not the 460 acres cited, but one hundred and fifty times as much. Suppose the Anopheles Brigade had been given two years ago this Lake Chagres and the other lake reinforcements; suppose it had been allowed the help of such vast sanitized areas, it would have had a chance to make the record it so naturally craved. Perhaps yet sanitists may mitigate their self-sufficiency and the Panama Canal be accorded a right chance for its execution.

To confirm the deductions and bring the analysis of sanitary conditions to the autumn of 1907, it is necessary to point briefly to one monthly example; say the latest full report of the Department of Sanitation—that of September.

Under date of October 12th it is officially announced:—

"The health conditions of the Zone continue good. As is usual at this time of year the sick-rate is decreasing. The sick-rate for September was 27.78 per thousand; for August, 29.02. The same rate for September, 1906, was 37 per thousand, etc."

We note that the divisor to get the record is still the number on the rolls, "41,062," while the number of effectives was 29,845. The French computing factor was their number of effectives.

The report continues: "In September, 1906, the total population of the Zone was 76,000." (The Message of December, 1906, gave it as 76,959 which our foregoing Tables VI. and VII. show to have been raised from 61,419.) "In September, 1907, the Zone population was 108,000." This would give an increase in one year of 32,000 or if the real figure deduced in Table VI. be taken, an increase of 46,681 in twelve months! This, it is needless to say, does not correspond with the net arrivals, with death allowances, for the year.

Of the 41,062 on the September, 1907, rolls, of whom on the average some 29,845 worked daily (77%), there were 11,217 not working. For every ten men working there was one man in hospital, one in sick-camp, and eight and a half dispensary treatments in the month, 55% of those who came for employment in the year left. There was a sanitary employe for every ten men working.

Were the Americans astonishingly healthy? What does this exhibit show? In this month of September, 1907, 618 Americans

were treated in hospitals out of 4,200—14 7/10% or one man in seven. "Only two died!"

There were altogether I. C. C. employes,

American 4,200
Foreign 7,462
——Whites 11,662
Colored 29,400

There were 3,030 admissions of employes to hospitals, of whom 2,132 or over two-thirds were WHITE. Of all the Whites, 18 3/10% went to the hospital. Of the foreign whites, 1,514 reached the hospitals. This is 20 3/10% or over one in five admitted this month, "when the health conditions of the Zone continue good." Their death rate was six and a half times that of the Americans.

Of the 11,662 whites and 29,400 colored there went to the *sick-camps 3,079.*

This is 10 3/10% of the effective force. For the 11,662 whites there were *16,010* dispensary treatments or 139% in the month.

Of the 29,400 colored the record tallies for September:

Admissions, Hospitals..... *898* or 3.05%
Cases in Dispensary.....*9,626* or 32.7 %

Their sick-camp rate is not separable. But such is "sanitation" at Panama!!

It is a mockery; out of their own mouths and medical records comes the impeachment.

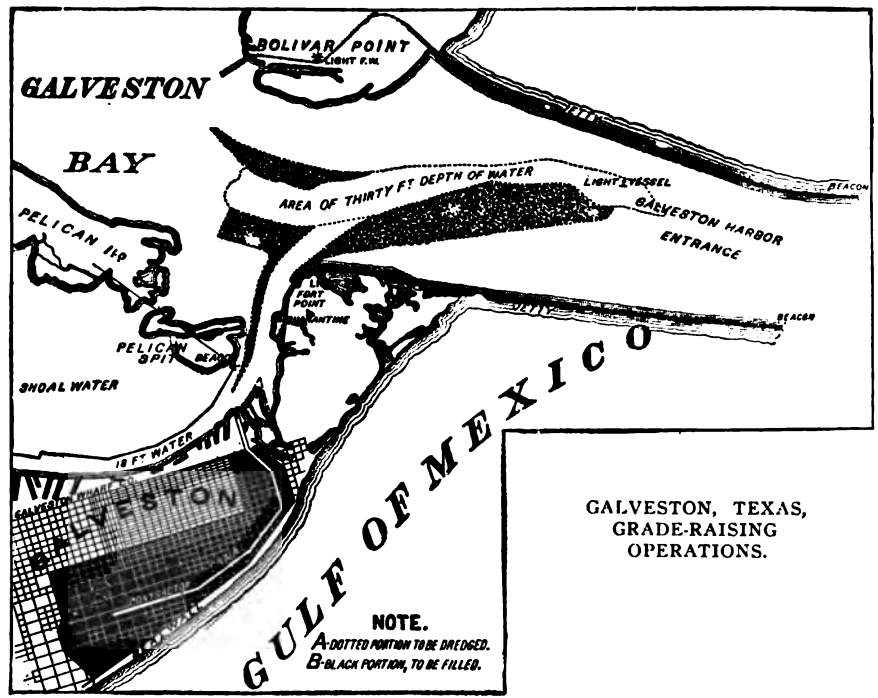
The hospital rate of the white is six times that of the colored. Why—when they are so much better housed, fed and cared for? The dispensary rate for the colored force is about two-ninths that of the Caucasian race. Why?

The death rate of the dark race was five times that of the American. Do men die *five* times as fast and take sick but one-sixth as often? Why? There seem to be pointings here for some startling conclusions. The need of radical sanitary retrieval is imperative.

It has never been the hills or the seas, but the low fever-hiving morasses which have overcrowded Panama's mournful mate and Monkey Hill, in solace rechristened "Mount Hope."

There would be plenty to sanitize still were the Isthmus with its created lakes but eight miles wide; plenty to do in making Colon, Mindi, Gatun, Culebra and Panama health resorts. All the rest may be water, and speedily, if there be

but the sovereign will—water and perfect sewage; water and sheltered men on water-borne machines; water and trade breezes across the wide lakes; water around the lock sites; villages on the water-environed slopes, and the plagues of the swamps buried at last forever.



GALVESTON, TEXAS,
GRADE-RAISING
OPERATIONS.

CHAPTER XXXI

LABOR.

The two departments of sanitation and labor are so interlinked and interdependent at Panama that they must be treated as allied. The facts regarding one carry consequences so directly into the other that an occasional restatement is unavoidable.

"Laborers are wanted at Panama!" The call has gone out from the Isthmus for half a century. In the last years of the French regime light dawned and the word went forth—the minimum of men, the maximum of water-borne machines and land plant invincible to rain. This was the final dictum of half a generation's experimenting. They learned their lesson hard, and they paid for it the price.

The French came to their Isthmian Canal with experienced, equipped and resourceful leaders. Many of these men had been at Suez. Through a decade there they had measured methods. They had tested ways. They were not novices at canal building. They did but gather up anew the strings of their old organizations. The very inaugurators of the work at Panama were Courveux and Hersent, the most successful executors of the eastern waterway. Further, their work was directed to a defined, exact, fixed end. They were not for three years beating the air trying to find out what they were for at Panama. They had come to build a sea level canal, and they laid their plans and evolved their program of attack accordingly. They provided plant and distributed forces in consonance with a rational system of execution. Yet their money went like water, and the sea level proved the Sisyphus load that 256 millions could roll but two-fifths of its way. They turned to a lock plan, but too late to save their cherished canal.

On the other hand, there was among the administration forces an element extravagant, unprincipled and impractical. This group began early sowing the wind which was to develop into the whirlwind. They bought in France entire shop stocks of supplies indiscriminately, and a fleet of ships was kept occupied in carrying to the Isthmus the unnecessary in nearly as large a proportion apparently as the needed. In the damp climate machines rusted rapidly, and warehouses had to be constructed

to house supplies. When the Canal Company's possessions were sold to us there remained still French purchases which had never been even opened. Human nature moves naturally along the same grooves. It has been seen in this series that our management had also an element extravagant and reckless. Purchases were made regardless of fitness or service, and our money likewise went as water.

French canal history is therefore an inconsistent, contradictory chronicle of the two elements, the one, sane, experienced and masterful, which pushes on in the face of overwhelming odds and achieves, as will be seen, the greatest feat of canal building shown in all human records. The other element, the evil genius in the management, drags the waterway with growing acceleration to ruin.

A summary of their labor conditions in 1886 gives this: "Most of the laborers at present employed are Jamaican negroes, who are valuable in a way as being acclimated partially, but who are not as valuable as is wished. * * * The company gets from twenty to twenty-one days' work out of this class in a month of thirty days. The government in Jamaica discourages the negroes of that island from going to the Isthmus. People on the Isthmus say the negro men are wanted in Jamaica for the plantations, while the papers of Kingston base the government's action on purely philanthropic and patriotic grounds, seeing that the negro returns from the Isthmus without money, frequently broken down in health, and if not so, in about the same condition as when he left Jamaica. * * * It is possible for a temperate and economical workman to go to the Isthmus, receive liberal pay and save something. The chief risk is that of health resulting from climate. Many of the reports regarding the death rate have been exaggerated, but it is not to be denied that the climate is dangerous, and extreme care is necessary for an unacclimated person to keep himself from fever. If full returns of the fate of those who leave the Isthmus after an attack of fever could be obtained, they could be combined with the records kept by the Canal Company, and some idea of the actual mortality be obtained, but this is not feasible. * * * Three hundred Kroonmen are at work now. They come from a region whose conditions of climate are similar and give promise of being valuable."

Laborers from Everywhere.—There were also some 500

negroes from Louisiana and other southern states employed. These men had come down in the crews of vessels.

The French, facing their insufficiencies, canvassed the desirability of bringing labor from southern China and the west coast of Africa. Before 1886 the company had a few coolies, and their frugality and faithfulness made them, from one point of view, very desirable. But Chinese labor had been tried before at the Isthmus with unfortunate results.

The French got their program early in hand. But in this new Isthmian field there was still much regarding ways, means and methods that had to thresh itself out in hard, costly experience with local conditions. They had at one time an American Steam Shovel propaganda. The official report of the Liquidator to the Court says briefly of its passing vogue:

"Certain contractors placed great dependence on American steam shovels of great power to attack not only the earth but the rock. But unfortunately this extremely ingenious apparatus required operators very experienced and the repairs were difficult upon the Isthmus. The results were disappointing, and they were supplanted."

There is much more to the same verdict, showing that in the competitive French testing steam shovels did not survive. Good as this tool unquestionably is in northern relatively dry lands, in a combination of rain, soft ground, great weight on a small base, debilitating heat and its insidious reductions of capacity to direct the complex motions, difficulty of repairs, scarcity of skilled operatives, the vexing and delaying collateral track and big and heavy car impediments, there results a serious limit to actual output. The ex-Chairman quoted as to accomplishments at the Isthmus that "twenty steam shovels do the United States work of four or five" in the rainy nine months' season.

Gradually with the French, as experience enlarged, the unfit and inferior tools and methods were discarded or superseded, and the survivals were what great cost and great loss perpetuated as most useful and successful. The summary of all their testing went forth in the dictate of one general principle, the minimum of men, the maximum of water-borne machines and land-plant invincible to rain.

An engineer of French times came to America recently on a crusade with this very battle cry, "Water plant, not land plant, the key to the execution of the Panama Canal!"

In 1886 the French, with their small, light cars and their diminutive Belgian engines in the Culebra and their water-borne excavators advancing from the Bays, were pushing the canal work vigorously. They had a tremendous plant in operation, literally from sea to sea. They handled in five months, from January to June inclusive, 8,246,969 cubic yards, the highest average monthly output ever yet recorded in Canal execution. In March the output was 1,426,100 cubic yards.

M. Rousseau, especially delegated by his government, reported in April, 1886, that in the month of January it had required, all departments told, ninety-five hundred workmen, using machinery of that date, to excavate 637,000 cubic yards, and estimated that proportionately it would take a force of 37,750 men to handle the output of 2,529,800 cubic yards per month in the dry, needed to realize the sea-level plan in the time appointed.

These figures excluded the dredge work, which he wrote "requires but a small personnel."

An Isthmian report of 1905 comments through a commissioner:

"The Panama Canal Company officials were highly paid, but they were far from home and its restraints; they were ignorant of the measures that we know are effective in warding off certain diseases on the Isthmus and a great many died."

In commentary upon the last remark it is a little astonishing what a very dark background our canal administration deems essential for bringing out its own phosphorescence. In the investigation of Panama Canal matters, Senate Committee hearings for 1906, a member of the International Board of Experts and an ex-Commissioner also writes this:

"Twenty-six years after the driving of the last spike of the Panama Railroad came the French undertaking, led by the maker of Suez, and for eight years money, champagne, absinthe and rum flowed like water. Then the dissolute and depraved—human driftwood of the nations—thronged to the Isthmus and joined in the constant carnival of dissipation, disorder and crime, an era of license and luxury, of starvation and misery, of corruption and veniality.

"Whatever qualities of honor, of self-respect, and correct living may have existed on the Isthmus before the advent of the railroad and canal, those possessing such virtues were

lost or sacrificed in the tornado of dissipation that came with these enterprises, so that the local government, whatever may have been the excellence of intentions of the governing class, was utterly powerless to stem the tide. Licenses for the privilege of open indulgence in vicious and criminal practices and monopolies sold to the government favorites yielded large sums to the public chest. There was no such thing as a self-respecting public opinion; there was apparently no standard of morality or virtue.

"The present government of the new Republic has an opportunity to show that similar practices to those of the past will not be permitted longer to prevail. There are provisions in the new constitution that look to the discontinuance of official monopolies and that do now prohibit games of fortune and chance, but the world will have a reason for withholding confidence in the sincerity of those who enact and those charged with the enforcement of those laws so long as the general treasury continues to enjoy a large income from officially authorized gambling and lottery drawings.

"It is not surprising that during the temps de lux, as the period of lavish expenditure of the French is still called—a time when every man and woman sought to participate in the orgy and profit by it—little thought was given to sanitation and hygiene, to pharmacies and hospitals, to asylums and infirmaries. Those who dropped out in the scramble simply languished and died. That the mortality was great was certain, and it would have been so in any climate where like sanitary and social conditions prevailed; but the death rate was undoubtedly large. It is for Americans to see if they cannot change those conditions. That we will do so is the confident belief of the sanitary officers and the writer.

"The French company was operating under a concession. The company had no police power. If wronged or injured personally or corporately, the appeal for justice had to be to a Colombian court.

"The company could not compel the inhabitants along the canal line to clean up and observe sanitary rules; indeed, there were no rules. If a village was reeking in filth it so remained until the people might abate the nuisance; but the French company made large expenditures in hospital construction and maintenance. An establishment that is to-day a notable one was built near the city of Panama, in a very

thorough manner, and it possessed all the appointments usually found in hospitals of its date."

The chairman speaking January 26, 1906, before the Commercial club of Chicago, said:

"The men under the French were poorly housed and poorly fed and the mortality among them was so appalling, that it spread throughout the world the belief that the Isthmus of Panama was the pest hole of the earth—a veritable hell of disease and death."

Manifestly, no blackness escapes in the setting for American achievement. It is a little humiliating though, is it not, that the boomerang strikes home with added force, since our death rate and hospital rate are higher than in the "constant carnival of dissipation, disorder and crime, when champagne, absinthe and rum flowed like water?"

Yet the ex-chairman continued unabashed:

"Never in the history of the world has any government or any corporation made such comprehensive and exhaustive arrangements for the health and comfort of its common laborers as has the government of the United States on the Isthmus, and nowhere else on earth have the sanitary rules been so rigidly enforced, with such successful results."

In the commentaries of the board and commission the aim seems to be to throw the blame for the French mortality on debased living, luxury and recklessness. This is unworthy and wholly inaccurate.

Debauchees do not through ten long bitter years hold to a nation's ideal and stand and die unstoried in her cause. The quality of mind and soul which achieved two-fifths of that stupendous task were not born of champagne and absinthe, be sure. Men are men of whatever nation, and great deeds are created in divinity, not depravity. If the sickness and death were but the fruits of the "tornado of dissipation," why, pray, is it worse under the virtuous American than under the French at the Isthmus? Perhaps with the full light upon our own sanitary situation we may feel less compelled to malign our predecessors.

Could the health conditions have been safeguarded and enterprise have been kept free from intrigue and graft so that the money might all have gone honestly into execution and a right lock type substituted in time, the French might have

had their Panama canal. But the sea level design, with the vast labor forces involved, was the millstone about its neck.

The years in which all these costly siftings and testings were made should hold surely some lessons for our guidance both as to labor, sanitation, tools, type and programmes of canal execution.

There came to the zone in French days a great influx of population, attracted by wages high for those times, though markedly less than ours. Nearly twice as many buildings as those of January, 1907, along the route, were occupied, so that it is fairly certain that the total population then was undoubtedly considerably greater than in January, 1907. They had no control in Panama or Colon, or, indeed, anywhere along the line, at all comparable to the authority our police and sanitary brigades possess and exercise. Yet they kept order with a very small force.

French Attained Marked Efficiency.—In everything, therefore, thus far examined, sanitation, direction, program of execution, fitness of tools and output, the French attained a marked efficiency and success.

We turn next to the Americans. One might fancy that with the railroad history and Panama history lived out at our very doors the moral would have been impressed. But the railroad story went back to our fathers' time and the French debacle was softening in memories.

Our first commission took hold of the enterprise with caution and conscientiousness. They expended money only where they saw right returns promised and they were slowly making haste.

Commissions have had trials of their own making and trials of being themselves made and unmade. Three have come and gone. The Walker commission went economically in their year of power. They spent of the first ten millions granted, but $1,129,666.23 to November 30, 1904. The next two commissions made the millions fly, if not the dirt.

Let us trace the processes of the Secretary of War by which he has pressed or been won or lulled to outreaching for laborers —laborers no matter who or whence.

Macedonian Cry for More Men.—When the American government took over the canal and set about completing it, a certain general system of execution was selected, with the Culebra for precedence, "the dry" as the method, and the

steam shovel for the adopted implement. This principle and method have been followed unbrokenly since. The estimates for the canal's cost, as made up by the 1901 commission, were based primarily upon this procedure, rating the output at an efficiency which the tool was expected to attain. The later commissions, urged soon by the need for getting better results, had two alternatives—to put through the work along the old lines by sheer force and weight of additional numbers in defiance of cost, or, acknowledging the inadequacy of their system, to adopt other and better methods. They chose the former. Hence, from the Isthmus went early, and has gone forth continuously since, the Macedonian cry for more men! Whence could they be sought?

Labor is not coming from France—the old lesson lingers. There is no English or German contingent, and no Irish brigade such as enlisted and perished in the Panama railway struggle. No Dutch levy like Van Hattum's vanished thousand comes again. The American negro reads too significantly and Argentine and New York suit better most Italians. There will be no Japanese. Enlightened governments are going to allow us their bone and sinew only when they are satisfied that these citizens will have every reasonable chance for health and survival. Contractors may accept imposed labor responsibilities, but when the inevitable crucial hour arrives it will be the government arraigned at the bar of government.

Cleanliness Is Fatal.—We began with the native Panamanian, but we threw him over speedily and hailed the Jamaicans as the only laborers. We fixed them some houses, the like of which they had never dreamed in, and brought them their own and inalienable wives—from Martinique. After three years word is passed that "clean cabins, clean beds, clean food, pure water, light and sweet air and sewerage are fatal to Jamaicans and their lungs give out." All the weedings and ten strippings a year of tropic growth from 460 acres between Cristobal and Corozal, all the mosquito netting and disinfecting, and the Jamaica negroes reported only the more forlorn, more unfit, more sickly. Bounty men have drummed the mid-coasts up and down; they have flailed the islands of the Caribbean. The provinces of Spain have been invaded, of Portugal and the "far off Azores, Italy and Greece." The lure of big pay and little work drew labor from Martinique. But presently a governor of France tied his natives to their

homes. It reached the mosquitoless malaria-free Barbados. They heard and thousands went to Panama, but these favored lands no longer hive. Several ship loads were won from other islands in "those liquid miles" of the Spanish Main, but most of the men went back again. So the authorities, shutting their eyes resolutely to the vanished millions, turn the leaf silently that public attention be not disquieted and call the chapter closed. After the negro—the Chinese!

In reviewing the labor history at the Isthmus it was remarked that the whole gamut of experiences of all kinds had been run by our predecessors of railroad and canal building. They began in frenzied, precipitate speed just as we, then called a halt to get ready, just as we. They proceeded next to house building, just as we, and gathered a very riot of useless equipment and purchases, just as we; they erected hospitals and infirmaries that were models, just as we, and their corps of physicians and nurses, disinfected and sanitized, just as we. The railroad began with the native Isthmian and Jamaican negro, just as we; sampled the sons of toil from many lands and ended with the Coolie from Canton, just as the Secretary of War. And tragic enough it was this Chinese experience.

It was commented in October, 1906, that it is of no concern to America what labor constructs the canal, since white labor cannot dig in the Isthmian sun and rain. The question is not fundamentally one of the individual man. The Coolie is industrious, patient, frugal, abstemious, hard-working, beyond any question whatsoever. For his many virtues he is most desirable, but what he is and what he represents otherwise are equally unquestionable.

Bound Men at Panama.—Does this not really concern America, and enormously? Does this not matter, as the experienced west knows; does it not signify that bound men shall not again live beneath our flag? For every reason—national, social, financial, economic and structural—it does concern this country, this continent and this canal. The Secretary of War and the then chairman have the distinction of being the first officials since emancipation days willing to advocate and to be sponsors for committing this government, which could not "stand half bound—half free" to the iniquities of the Chinese indenture system. The successors of Wilberforce, after overturning the ministry which had affronted the

moral sense of Britain, have just undone it and given it the coup-de-grace in its last English foothold—South Africa.

There have been bound men before at Panama. The treasure-bearers of Predarias were victim Indians. For such Las Casas wrote the most heart-wringing of narratives, and for their masters the most damning condemnation of all literature. The railroad pioneers experimented with bonded Chinese.

In their stern task of forcing the rails across the strip they had brought a shipload of between 800 and 1,000 Coolies.

Mr. Tomes, a contemporary, invited down as one of the distinguished company to the inaugural, published details of this experiment.

"No sooner had the over 800 survivors landed than 32 of their number were struck down, prostrated by sickness, and in less than a week 80 more were laid by their side. Whether it was owing to the deprivation of their habitual stimulant, or to the malignant effects of the climate, or homesickness, or disappointment, in a few weeks there was hardly one of the over 800 Chinese who was not prostrated and unfit to labor. They now gladly welcomed death and impatiently awaited their turn in the ranks which were falling before the pestilence. The havoc of disease went on and would have done its work in time, but the Chinese could wait no longer."

Then follows the detailed account of the manifold ingenious ways in which they committed suicide, all but about 200 who were sent away to Jamaica. This is the story of Matachin, "dead Chinese town."

This Chinese experiment was tried recently in the Congo with the identical results herein recorded. Some became ill, panic seized the rest. Being bound and penniless, they could not escape, and, as at Matachin, they all made crazily away with themselves as the lesser evil.

No race takes alarm and stampedes in the face of illness or epidemic so uncontrollably as the Chinese. The writer chanced to be at Hong Kong in 1901, when the plague having carried off but its first few victims, the English began fumigating and awoke the first misgivings. Seventy thousand fled precipitately in a week, and business among the natives came almost to a standstill. The whites paid little heed, and seemed to have no personal solicitude in the mat-

ter, and during the year that followed but few whites died. The disease made havoc, however, with the natives.

No directorate should consider Coolie labor at Panama without distinctly canvassing this race trait. It becomes especially important in view of the peculiar susceptibility of the Chinese to Isthmian disease.

The summary of the railway building experience is given in these words by one of their writers:

The rate of mortality:

Natives of all races	2%	per annum
Negroes	2½%	per annum
Europeans	3½%	per annum
Chinese	10%	per annum

This latter figure does not include the suicides of Matachin.

The French started to repeat the Coolie experiment before their failure. In 1886, being sore beset for labor, they canvassed the South China field and West Africa. They had but few Coolies, however, among their forces. They relied chiefly upon the negro labor of the Atlantic Islands, Jamaica and Martinique supplying most.

Labor's Short Life at the Isthmus.—French history confirms that the number of laborers who persisted longer than two years at work on the Isthmus were very few. Senate Document 303, Fifty-seventh Congress, has in the testimony of a noted surgeon, this:

"There is not a single French engineer who had been able to attend the work beyond a year and a half, although the contract called for two."

Referring to the importation of labor for the Panama railroad, Liddell says that "the services of laboring men from the United States could not be counted on for three successive months. Before the end of the second month one half of the force was on the sick list, or enfeebled by sickness already sustained."

A continuous stream of men poured in and out and the problem was ever the same—how to replace the incapacitated and the discontented, and keep the quota needed.

Mindful of this lesson, the Chinese were to be indentured for a two-year term of bounden service. Contemplating the 1906 hospital record of 159% per annum of the effectives or average working force; the fact that Chagres fever or malaria once well in the veins lowers the already low efficiency of labor to a point where it must be replaced by new blood; the discontent of Chinese labor in an alien land whose lan-

guage and customs are strange, under a lately boycotted flag, whose barring restrictions have banished them from all its territory except this zone; in the summary of all these aggravated elements, the former history is not likely to be reversed. The number willing to re-enlist and sufficiently untouched by disease to be selected for retention beyond the two-year period will be too few to be worth calculating. But let us figure the best chance.

The contingent of laborers for the 85-ft. lock-flight project, which, at the relatively high rate of the French output in 1886 must be kept at the Isthmus in addition to the 1906 employes, is over 31,000. If the efficiency during the three years past be taken as a standard it must be very much higher. If, next, 7% only are to die and even a very minimum proportion of 3 to 6% per month be for longer or shorter periods retired to hospitals and homes of convalescence, it is ultra conservative to estimate that 8% of the force besides those who die will have to be repatriated because enfeebled. To maintain a force of 15,000 Chinese at the Isthmus, then, something like this must be faced.

What the Chinese Proposition Involves.—In nine years there must be brought, roundly, 95,000 Chinese, of whom 9,500 will die; 10,500 will be invalided home; 67,500 (15,000 at 50% per annum) will enter the hospitals, and there will be 190,000 fares across the whole Pacific ocean. If further a force of 31,000 Chinese is required—a need more than which must exist in order to complete the excavation in eight years, especially if the recruiting in the West India Islands fails—the above figures will be much overdoubled. The situation is truly interesting.

We have gotten into a way of considering the labor problem from one side alone—our own. There is a Republic of Panama down there at the Isthmus, and she has rights and susceptibles as well. It is inevitable that some proportion of those who come to build our canal shall become colonists and remain among her permanent population. The Panamans are Spanish and white, so that every argument which could mitigate against bringing certain peoples into our own midst mitigates also at the Isthmus. The Republic has a stringent Chinese exclusion act. Recalling that the efficiency of black labor has been given officially as one-third that of white, the number of men that shall yet be required

for putting through the canal is enormous, unless a radical change in design and method enables machines to supersede much of the hand labor. It would be a grave mistake to introduce on our work an element which must be very objectionable to the Panamans, as their exclusion laws show. Even with arrangements for the ultimate return to their country of Chinese, the influence through eight years is to be weighed. Panama is a country of small population. Outsiders hold a much larger proportionate place than if her territory were densely peopled. From the social point of view it is no light thing to introduce into the zone a vast lower class population of whatever race—it should be certainly of the least objectionable race possible.

If by any great good fortune Spanish and Italian laborers can be gotten in sufficient numbers, it would be indeed, both for Panama and for ourselves a most providential solution. The distance from home being very great, return would be more difficult, and these men might by very force of limited exchequer be held at the Isthmus sufficiently long to become somewhat acclimated, and so stick the situation out better than the negroes have thus far. But more should be done to insure them health conditions than has been undertaken in behalf of the West Indians. "A thousand a month," as the chief engineer suddenly telegraphed, is encouraging. Is this "thousand a month" net? Till the proportion of departures, hospital detentions and death changes, no revolution will be wrought at Panama by this number of Gallegos. It is not possible that the great desirability of substituting machines for men will ever be reversed —and surely this desirability is not superseded by anything yet developed or ever likely to develop at the Isthmus.

The ex-chairman, speaking at Chicago, says: "In view of these statistics down to October 31st, and of the gradual decrease in both the sickness and death rates among all classes of employes, we feel justified in announcing to the world our beliefs that we are now in a position to invite white labor in any quantity from the United States to assist in the construction of the canal, and at the same time promise them an immunity from disease equal to that which they would enjoy in our southern states under like conditions of employment." One wonders what statistics the chairman is passing around. He adds:

"In addition to making the Isthmus a healthy place in

which to live and work, we have accomplished many other and scarcely less difficult tasks. What sophistry!

"We have assembled the larger part of the great plant with which the canal is to be constructed, and we have completed the engineering plans upon which the work is to be carried forward."

What the 85-ft. Plan Requires.—What necessitates at Panama these vast forces of men? Primarily the type of canal undertaken. The 85-ft. plan as designed requires such profligacy of human labor in the excavation and distribution of material that if the authorities are driven to resorts when it is only begun, what is to be expected later? There could hardly be discovered a canal project to which labor-saving, rain-defying or water-borne plant is less applicable than to this scheme which sorely needs it.

There are 110,015,000 cu. yds. of excavation and embankment—and such embankments!—43,480,000 cu. yds. in the high Gatun dam, the Pacific dams and the railway fills to be handled by "dry" methods.

Besides, there are 12,960,000 cu. yds. of dredging at 25 cts. in Lake Gatun above the plane of 40 ft. There are also 1,680,000 cu. yds. of dredging at 25 cts. in Lake Sosa above the plane of 10 ft. To dredge this 14,640,000 cu. yds. after the lakes are full will certainly take a large plant two years, as the material is of mixed and not particularly favorable character. Delay can be avoided therefore only by employing dry instead of wet methods, and this brings the total to about 124,615,000 cu. yds. Allowing a man the efficiency of the French and rating him 70 cu. yds. per month, would give for executing the canal the equivalence of 1,780,800 months' work. But this allowance is for the short favorable dry season, and the difficulties of the wet season must be reckoned to diminish the output by 50%, and hence to increase the time equivalence to 3,116,400 months.

To perform 3,116,400 months' work in a hundred months will take a force of 31,164 men. On such a basis at least 31,000 men will be required in addition to the 1906 force, presumably now fully employed or to be needed later for sanitary and the vast concrete works. This gives at the Isthmus a force varying between 57,000 and 61,000.

According to the published official United States report, there were carried on the rolls in July, 1906, 28,041 men, of whom

25,000 were laborers and 3,000 white men. The Isthmian report gave for August 29,555 men. In May, the effectives including the railroad, were around 21,000. The French never had so many effectives by 4,000. Yet the superiority of modern methods, tools and labor-saving devices has been much vaunted. It has been one of the enigmas of the past what this army was doing at the Isthmus.

Water Plant vs. Land Plant.—It is a fact inherent in Isthmian topography that the program of execution, the number of men employed and the unit costs must differ with every plan, and differ widely between some plans. If there are two locks there is one program, four another, and six another. If locks are conjoined in flight, the concomitant dams must be huge. The combination of locks in flight and vast dams dictates its special program of execution, calling for a very large labor force. If the locks are separated and not in flight the concomitant dams become small, a wholly different program of execution results and the labor force proportions accordingly. If, further, a predomination of water plant be substituted for land plant, radical changes result, machines taking the place of many men. The newest water-borne excavators give an output enormously above the steam shovels and at prices radically cheaper. Fewer men would be required, and those employed would be much more largely skilled whites. These being under shelter and being surrounded by the extensive water areas of created lakes could work at Panama. A different situation is at once introduced. It is shown by navy statistics taken over a convincing lapse of years that men afloat on large water areas have from 12 to 60 times the immunity of men ashore. It is not a task, then, of digging with shovels in blistering sun or of operating land plant in connection where men unprotected become soaked in the torrential rains, or of manœuvering cars and steam shovels whose output under nine months of continuous handicap become but a moiety of their full capacity. Water plant is indigenous to rain; water is its natural element. The rainy season could not curtail its record, and mud and settlings would have no place in its recitals. The great canal wage expenditure could go largely to the white men of America. The whole point of view regarding the method of execution is seen to be fundamentally revolutionizing.

BATES' HYDRAULIC

E "ARCHER," AUSTRALIA.
H. P.

CHAPTER XXXII.

Labor and Execution.

The waste and deplorable cost of execution will be probably condoned in the great general desire for the canal itself and an indulgent treasury will pass out the millions. But money is not the only thing. The canal must somehow take on greatly increased activity during both the wet and the dry season, if this decade is to see the completion of the 85-ft. plan. Time, cost and volume of labor all unite in demanding some substitute for men. The introduction of supplementary water-borne excavating machines is one of the most urgent reforms desirable at the Isthmus.

With lakes created, these machines could come in on the fronts to assist the excavation of the central mass. The proposition of canal construction would become enormously simplified and the time of building could be materially reduced. But the temporizing, the wastefulness and the sterility of present methods apparently have not yet been sufficiently evidenced. The government must thresh out its experiences all anew, as did the French before it.

Saturnalia of Orders for Supplies.—The first Chief Engineer bored the Bohio dam site and the 1901 "85-ft." project to its ignoble collapse. It was a good thing, the best thing he did, and worth all its cost to him and the country. In the wreckage, the first Commission disappeared—and the sea level and the Culebra pre-eminence theory reappeared. It came first to Panama with the magic purse of France; it mushroomed again in the magic purse of the late Chairman at Washington. The free hand and the full hand inaugurated the saturnalia of orders for everything conceivable and inconceivable—and the word went broadcast to all the world for men, men, and more men. The army of workmen started the invasion of the land of gold and silver promise. In 1903 the number of paying through passengers across the Isthmus, distinct from local traffic, numbered less than 2,300. In the two years from October 1, 1904, to September 30, 1906, the arrivals and departures totaled 159,320, of which at least 150,000 are directly attributable to the wild labor propaganda and undigested program of the Secretary of War and the Commissions. Of the 101,361 arrivals, about 96,761 came seeking, a very few to establish business, all the rest

to get work. The net gain of population exclusive of those nearly 5,000 immigrants who died, was to September 30, 1906, about 39,000.

This vast influx was invoked by the policy of the Commission and the Secretary of War. It was promoted and augmented by active recruiting, and was stimulated by a bounty of wages to both white and colored higher even than that paid by the French, and 53,339 approximately represent the army of the seekers who came and went away again, apart from the ordinary through travel via the Isthmian route. So many had come, had tested, had had enough and could leave.

Sanitizing the Zone.—One can understand in this great movement why with the advent of the last ex-Chief Engineer everything was made subordinate to the great task of providing hotels, houses, quarters, barracks, hospitals, to repairing the disease saturated structures of the French and to the effort of sanitizing the Zone. What was there to do? They must either stop the flood they had themselves loosed or try to take care of it and get ready for canal digging besides. Execution demanded yet more men under their design and system, so they must prepare for yet larger labor forces. They put every comer to work and kept the world-beating recruiters engaged also.

The Chairman, with the sanction of the Secretary of War, had bought and brought upon the Isthmus a very avalanche of material and supplies. It took thousands of men to shovel these away—somewhere. Three thousand unlabeled cases went down the neighboring coasts in search of owners. Most weathered in the open until warehouses could be built and cranes could be imported to disentangle their low mountain ranges of boxes.

Next the chosen plant, the steam shovel was to be set up, and this in turn called for a superfluity of labor on Culebra's maze of tracks and terraces. These they could not or did not adequately drain, and each platform of ash-like earth or rock became a quagmire under rain. The slides demanded also more men. They drained the states of steam shovel operatives, masters of a special art, and gave them a lavish wage, in futile effort to secure the output which the estimates had been based upon, and which under the nine months' rain was proving impossible of realization. The plant embraced the heaviest steam shovels and the heaviest

cars, all unsuited to the nine months' predominance of seas of mud.

On top of all this came the last 85-ft design with dams more mountainous than ever, and lock flights of stupendous masonry, and the certitude of the carriage to the vicinity of Gatun by rail of fifty million tons of plant, rock, earth, cement, sand, crushed stone, timber, steel and supplies, and of twenty-five million tons more to the dams and locks on the Pacific side near La Boca.

The house building for the employes took further impetus. On September 30, 1906, $3,650,000 had been expended for buildings. By June 30, 1907, this item had mounted to $5,862,384.90, and was rapidly growing. The concentrated and all-pervasive effort, therefore, was to take care of the swarms already arrived and further contemplated. Canal excavation was the collateral interest.

An Army to Fight Vegetation.— The Sanitary program called further for some 5,000 men for clearing and keeping the vegetation cut down. The ex-governor drew attention to the fact that in the tropic Isthmus from 3 to 6 ft. in growth monthly is normal, and must be combated, so a large contingent must weed and clear and fight the vegetation.

Daudet in one of his stories has personified a forest on the flank of a river. While the forest slept its winter sleep some overdaring pioneers effected a footing. But the spring came and the rains and the sun. They and the earth whispered together and sent their legions of vegetation which overwhelmed the clearings and the cabins, drove the settlers to the water and obliterated all traces of the invasion. Panama has a jungle forest which in a few weeks takes back dominion of every uncontested foot. This large corps of about five thousand men are continuously engaged in fighting vegetation. From the reeking soil of the noxious marshes issue unendingly also the visible and the invisible presences which wage their battle and take toll of health and life. The forest and its microscopic myrmidons stop only at the water. Sovereignty can be permanently wrested from it by this one agency alone—water—water which shall drown deep its pestilence and its power. The keynote to salvation here nature has herself appointed. The deluges of rain through nine months of the year are her dominating and determining condition. Why will men not ride and rise

on a submissive alliance rather than futilely combat? The following was the situation at the end of 1906:

We are doing no canal work at Colon; there is a steam shovel in a siding at Mindi, two at Gatun making a railroad yard—they cannot be excavating the lock site, for this is to be located by the "three expert engineers" in April, 1907. there is nothing being done at the Gatun spillway, and nothing until one arrives at Bas Obispo, where there is a crusher which it took two years to get installed and paid for. Then along the great cut in mid-November were 26 shovels, some 21 in the shops on the hill, one at Pedro Miguel and one at Miraflores—and an old French dredge at La Boca.

This at the End of Three Years.—The rest of the work is railroading, building, sanitizing and distributing the millions of dollars' worth of American purchases. Thousands of men are to be counted among the carpenters, the "weeding engineers" and the armies receiving, stowing away and distributing "material and supplies."

The Chairman, speaking January 24 before the Knife and Fork Club, Kansas City, said:

"All available forces of laborers should be concentrated upon sanitary work, the construction of quarters, the railway enlargement and the location of dumping grounds for the spoil." This still at the end of three years!

The force far outnumbers that of the French at the zenith of achievement, when their tremendous plant was digging everywhere from sea to sea. We have as effectives, including the railway, about 20,000 men, while the French had 9,500 effectives when the prism they dug was 637,000 cu. yds. a month, in January, twenty-one years ago. With over double the force we have achieved about five-sixths of their output. "Their toy plant!" It is extraordinary what all the American force has occupied itself about.

One of the latest books on the subject of the Panama canal reports regarding wages as follows:

In this connection Mr. Stevens says: "On the basis of the present rates of pay for West Indian colored labor, which is the lowest grade of labor, we are paying 20 cts. silver per hour, and on the 8-hour basis, to which we are confined by law, it is $1.60 silver per day, or 80 cts. gold. The relative efficiency of this labor as compared to ours at home is about three to one. In other words, we are paying to-day for this labor $2.40 gold, or $4.80 in silver. Close

inspection of the different gangs, which extended over at least five months, demonstrates very clearly that the average superintendent or foreman, either white from the northern states or colored from Jamaica and the other West Indian islands, has never been able to work continuously more than 50% numerically of the different gangs. . . . Instead of obtaining a fairly continuous amount of labor, as we do from gangs here at home, one-half of the efficiency of this colored labor is lost, owing to their deliberate, unceasing and continuous effort to do as little work as possible. In other words, instead of our colored labor costing us $2.40 per day, the real situation is that we are paying twice $2.40 gold per day, or almost $5 for 8 hours' labor."

"Nor is the item of wages by any means a full measure of the excessive expense entailed upon us by the necessity of employing low-grade labor. Not only are we paying for this 300% of its true value judged by our standard, but the employment of it entails upon us in incidental expenses, connected with housing, feeding, hospital treatment, supervision, etc., probably three times as much as would be expended upon one-third the number of men.

To put the statement in another form: White labor, if it were practicable, would do the work upon the Canal at a wage of $2.50 gold, per day. We pay for colored labor of 30% efficiency, 80 cts. per day, which would make the rate practically the same, but for the fact that the colored laborer works on an average only one-half the time for which he draws pay. Hence our colored labor costs in wages twice as much as would white labor. But since it is necessary to employ three times as many of the former as of the latter to perform a certain amount of work, our incidental expenses, which may be reckoned on a per capita basis, are probably three times as great in one case as they would be in the other.

The West Indian laborer entertains the idea, not without good reason, that he is indispensable to the progress of the operation and the only prospect of getting good work from him depends upon creating competition by the introduction of Chinamen or some equally efficient labor."

The eight-hour restriction has since been removed by Congress, so that some small modifications of these results should have been secured.

They Came; They Saw; They Departed.—The movement of the people to and from the Isthmus, including the travelers who crossed from October 1, 1904, to October 17, 1906 (two years) is closely as follows:

Entered.	Departed.	Remained.
101,361	57,959	43,402

Another table gives—

The increase by immigration for 1905.....19,005
The increase by immigration for 1906.....24,409
making a total of 43,414. This includes the white and colored.

During these two years the deaths on the Isthmus were:

May 1, 1904, to April 30, 1905	1,200	100 per mo.
April 30, 1905, to August 31, 1905	975	244 per mo.
Month of Sept., 1905 (missing) estimated	250	250 per mo.
October 1, 1905, to October 1, 1906	3,636	303 per mo.
Total, about	6,061	

In the period from October 1, 1904, to October 1, 1906, there died on the Isthmus, as nearly as may be deduced from voluminous but not entirely complete statistics, 5,561. The population in the spring of 1906 was ascertained by official census. It was (exclusive of some arbitrary assumptions as to individuals missed) 54,949. Taking the net gain of arrivals in the months following, the population in October, 1906, was close to 62,550.

The natives are malaria-saturated and largely immune to yellow fever, and they have a lower death rate than the non-immunes. One may safely conclude that less than 40,000, and probably about 39,000, remained alive October 31, 1906, and that the rest had died in two years. This means that the annual death rate of the arrivals was high, but how high it is difficult to determine. It will be seen that the rate for whites is fairly normal, and of the net arrivals fully one-eighth were white—consequently the annual death rate among the colored from whom the laborers are drawn, was very high, as was shown indisputably in the sanitation presentation. The high mortality, while not generally known or credited here, must be known in the islands whence most of the laborers came, and it is undoubtedly one of the ruling reasons for the marked falling off of Isthmian recruits.

As the last rainy season advanced the mortality doubled, as it nearly always does. Immigration is then seen to begin falling off.

The net arrivals in 1906 were:

January	3,406
February	3,702
March	3,493
April	2,094
May	3,715
June	459
July	1,479
August	1,202
September	979

This is to say, in the four months, June, July, August and September, only a few more stayed than in the single month of May.

One Fever Cures Another.—One West India Island after another closed its doors. Those who returned took some

word back, and the fever to go was cured by the fever which they had found—"similia, similibus curantur."

The Report of 1906 reads:

"During the year there were employed on the white or so-called gold rolls, in the United States, 2,281, on the Isthmus 2,035, or a total of 4,316.

During this period there were 2,525 losses from the service, either from dismissals or resignations, leaving a net addition to the white, or so-called gold forces, during the year of 1,791."

In other words, in the Commission service (and this does not count the railway service, which is kept separate), out of 4,316 men employed, but 1,791, or 41½% stayed—and 2,525 left for various causes—what proportion invalided or dead does not appear.

Of the 25,034 laborers from the West India Islands 12,840 left; that is, 48½% stayed, dead or alive. More colored than white people proportionately, stayed, but many more proportionately, died.

The report continues:

"The supply of men received from Barbados has been continuous, and this immigration has necessarily depleted the population to a large extent, as far as able-bodied labor is concerned, so that our recruiting work there is becoming more difficult, and it is only a question of a few months when it will have to be temporarily suspended. The laborers brought from Martinique were recruited under verbal agreement, and the new emigration laws which are now being enforced on that island will prevent us from doing any work there. We have maintained no labor agencies on the island of Jamaica. The Jamaicans that have come into our employ have been entirely of the independent class, coming of their volition. The number shown as having been recruited from coast towns and small islands includes the Spanish laborers that we have received from Cuba, three ship loads from the Windward Islands, and a few hundred Colombians."

The Man with the Pick and Shovel.—Of the whites appointed in the United States in 1905, over 25% failed to go to the Isthmus. In 1906—the proportion was—positions offered, 4,869, accepted, 3,962, reported for duty, 3,243. That is—again 25% failed to go to the Isthmus and of those who went about 60% left.

The supplemental report of General Geo. W. Davis, excised from his main report of November 1, 1906, by the direction of the Secretary of War, contained in addition to its suppressed indictment of the management of the Panama Railway, this remark:

"It is useless to discuss the white race for heavy outdoor work with pick and shovel, in the mud and rain, on the Isthmus; no one has ever succeeded in obtaining such a force of the Caucasian race. Negroes from the southern states would of course be available, but the expediency of bringing them here is doubted, for they will be immediately placed in competition with their own race in the vast numbers that are already here, and I should not expect that harmonious relations between them would result; especially if one were paid wages current in the United States and another paid the wages current on the Isthmus. It is important that measures be taken to solve this problem as soon as possible."

Next the management, under the direction of the Secretary of War, turned anew to Coolies, for the minotaur of the 85-ft. scheme must be fed. Did any one tell why the net gains of labor immigration fell off? The Commission, sought the only other recruiting ground, the mountains of Calabria and the wharves of Genoa and Naples. They started another crusade among the Gallegos.

The California Congressional delegation have lined up first. They went to Panama in mid-December to investigate for themselves the need for and the desirability of Chinese labor and its relation to the canal. On their arrival the reports indicated the advent of serious reservations in the official program. January 2, 1907, only two weeks after the delegation showed such firm front, the Chairman was reported in the following statements:

"Washington, Jan. 2.—This report only tends to confirm advices we have been receiving from the Canal Zone. It is now practically assured that it will not be necessary to employ Chinese labor at all in the construction work on the Isthmus. Of course, if the class of white labor, such as Portuguese and Spaniards, now coming to the Isthmus in large numbers, is not large enough to meet the demand, the deficiency will have to be made up out of coolie labor. The construction of the Canal is the prime thing to be considered, and we will have to get the labor wherever we can, but it is now almost a certainty that enough labor can be secured without resorting to the coolie, who, you can be assured, will be employed only in the last resort."

It will be well if the pernicious 85-ft. design be a last resort also. Meanwhile, invitations had been issued to contractors to become "Superintendents of Construction" at a percentage of canal costs. The first proposition made the superintendents responsible in part for the "85-ft." engineering. The Chairman withdrew these invitations, announcing that contractors did not believe the engineering reliable or

sufficient. He substituted therefore the proposals of December 12, wherein the winning bidder should be agent of construction simply, with no technical responsibilities.

The lowest bidders have, after certain preliminaries, complied with all requirements, and just as they are waiting for the formality of acceptance, a leading paper in New York publishes this:

"**Economical Completion of Canal in Seven Years Indicated.**—Washington, Feb. 5.—Just as the President and Secretary Taft are engaged in the difficult task of determining the eligibility of the contractors who have submitted bids on the Panama Canal, there has arrived from the Isthmus a report which is calculated to make them pause. The fact is that Chief Engineer Stevens is digging the Canal, and is doing it at a rate which the largest contractor would find it hard to equal; that he has at his command an ample supply of satisfactory labor, and that, at a cost of at least $7,000,000 less than the lowest bid would come to, the great channel is being constructed at a pace which, barring accidents, will see its completion in seven years. In the light of these facts, the abandonment of the contract scheme is more than likely.

More than half a million yards of earth and rock were taken from Culebra cut during January, the official figures being 566,750 yds. January now stands as the record month, with October next with only 325,835 yds. to its credit. Because they were in the height of the rainy season, November and December showed a considerable falling off; but that is past now, and the Chief Engineer is pushing the work with characteristic energy.

Already there is engaged on the Isthmus a force of practically 25,000 men. The January report shows 15,604 employes carried on the "silver roll," 3,881 carried on the "gold roll" and 4,400 employed on the Panama Railway, so that 20,000 are actually employed at digging the Canal. There is every reason to believe that Mr. Stevens will be able to bring the average monthly excavation up to 1,000,000 yds. from the Culebra cut."

"Five hundred and sixty-six thousand seven hundred and fifty cubic yards!" "So that '20,000' are actually employed at digging the canal"; 566,750 cu. yds., after three years' preparation and forty millions of expenditure! How humble is our expectation when this can make us thus jubilant and vainglorious. Only three months of favorable season exists. The message announces, "In the rainy season the steam shovels can do but little in dirt, but they work steadily in rock and the harder ground."

Measured by the actual efficiency rate which the French achieved in January, 1886, when 9,500 effectives got out

637,000 cu. yds., 20,000 should have handled in this January. 1,330,000. Instead, they have handled about 42% of it. The facts appear to be that the experienced builders of Suez transplanted to Panama got in results over double in the dry season as much efficiency per month per man as the Commission is securing, and the French sanitized, built houses and tracks and installed plant as truly as we.

Recalling the French financial history, this is surely a very serious condition, and one concerning vitally and fundamentally the whole undertaking, especially as labor and superintendence are being paid much more than under the French system. If some radical betterment is not effected the inescapable logic of the facts is that the waterway must cost many times what Congress has allotted to it.

In his special report to the Secretary of War April 23, 1906, the Chairman says:

"Chief Engineer Stevens during the month of March, without making any special effort, but following the general policy of the work herein outlined, removed 240,000 cu. yds. of material, with an average of 107-10 steam shovels working. The reports up to the 15th of this month indicate a still greater degree of efficiency in excavation. He believes that by July or August he will have 40 shovels installed, and will be in a position to remove approximately 1,000,000 cu. yds. per month. The actual cost for material handled during March, figuring in contractor's expenses, was 53½ cts. per cubic yard."

In July, 1906, the output was but a quarter of that predicted. In January it is 57% only of that predicted, and the management has 52 steam shovels available, according to the Kansas City speech.

On September 30, 1907, there were according to the official report of October 16, 1907, 29,845 men "working," and 41,062 "upon the rolls." From this, it appears that 11,217 were not working. During the month, 3,381 were admitted to the hospitals, of whom *3030* were "employees" and *351* "non-employees." At the end of the month, 1,200 were in hospitals, of whom 952 were "employees." Besides the eleven hospitals there were thirteen "sick camps" into which went 3,079 employees and besides this 25,641 dispensary treatments were given.

Roundly then, during September, 1907, 10% were admitted to the hospitals, 10% were admitted to the sick camps, and the dispensary cases totaled 85% of the effective working number.

It is no wonder that 11,217, or 23% were not working.

In the fiscal year ending June 30, 1907, the effective force showed an increase of 9,846 over the year before. To secure this 20,884 were brought, of whom 55% left.

In September with 29,845 effectives an output of 1,517,412 cu. yds. was reported, of which 582,192 cu. yds. was dredge work *accomplished by nearly 345 men.* Then with 29,500 effectives 935,220 cu. yds. were excavated. This is 35 cu. yds. per man. It will be recalled that in January, 1886, 9,500 effectives under French management got out 637,000 cu. yds. or 67 cu. yds. per man. The French record still stands at nearly double the American, whose October, 1907, rate is 37 cu. yds. per effective, exclusive of dredging.

In the speech of the retiring Chairman before the Knife and Fork Club, in Kansas City, Mo., a general statement is made showing the great accomplishment in canal building achieved during his reign. As this is his last general review, early in 1907, it is quoted:

"Altogether the surface in the Culebra cut has been brought down to 65 ft. below the level left by the French. A large amount of the excavated material has been used in filling for the railroad yards and double tracking of the Panama Railroad. Much of it has been taken to old French dumps recently placed—two at Miraflores, two at Pedro Miguel, one at Rio Obispo, one at Bas Obispo, and a very large one, two miles long, at Tabernilla."

When an authoritative statement like this is printed at the government offices in Washington and is given out by the Chairman directly in charge of such an important national work, at the close of his ministry, it is supposedly true and accurate, not in the narrow letter alone, but in the spirit of universal comprehension. The Isthmus is five days removed; most American citizens have not been on tours of inspection; their faith and support are given loyally to the Panama Canal because it supposes its public servants are trustworthy and open. Could a single auditor or reader of that speech understand from it the fact; could a single mind deduce that in one spot a very narrow septum left by the French, from the east to the west bank of the Culebra Cut had been removed, a few feet wide on top and some 60 feet high?

Can any man interpret the digging away of a septum equal in mass to the excavation for a New York office building as "altogether the surface in the Culebra Cut has been brought down 65 ft."?

There is nothing so dignifying as truth.

"The time required and consequent cost will be more dependent upon the kind of a canal to be built, and to a far greater extent than has been, I fear, appreciated."

Thus the late Chief Engineer is moved to write:

Key is at Mindi.—The truth is finally to be acknowledged, that the right, balanced, saving Canal design is the foundation of the whole matter and the labor situation is to be met not at Canton but at Mindi.

When the resourceful and versatile American is confronted with a labor difficulty, his first and safest thought should be to minimize the need of labor, not to go searching the world over for more of it.

The clothes the people wear could not be made by hand —there is the sewing machine; the ore of the Pittsburg Steel Mills could not be provided by hand—there are a hundred inventions to do this work.

Machines existing or to be designed are not the only need of the Panama Canal to supplement and minimize labor; the first thing, the thing of all others, is to adopt the easiest plan to execute, the one with inherently the lowest unit costs, the one demanding the smallest plant and the plant operated by the fewest men. This is the line of least resistance, the line of most rapid execution, the line of the greatest national independence, the white man's line, not that of the indentured slave.

The efficient solution of the labor situation is, under the right waterway plan, to reduce to the minimum the number of men demanded by enabling floating machines to attack as much of the Canal length as is in any way practicable.

First the Lakes, Then the Canal.—No design meets this situation at all comparably with the one which creates first Lakes Chagres and Panama, reducing the land width to the distance from Pedro Miguel to Travernilla, sixteen miles in the first year. Forty-seven miles of width cut down to sixteen miles in twelve months would augur a living chance for the Canal. A year later by impounding but 15 ft. of water at Gatun the land width would become reduced to the distance between Pedro Miguel and Obispo, 8 miles.

These dispositions would leave a relatively small land force at the Mindi, Gatun and Sosa locations and between Pedro Miguel and Obispo. The dry Culebra excavation

should go to the place of least rainfall on the Isthmus—the water front of Panama.

The first requirement is to make a balanced, harmonious, inter-related unity in the right design. For this it must be recognized that there should be incorporated no locks in flight, then four locks or two locks only become necessary at Panama. A two-lock canal—one lock at Mindi, the other at Sosa—is a very good Canal, in certain respects the best, and every dam would be upon the rock. The four locks, if four be selected, must be separate. This change means everything technical, financial, executive, sanitary and ethnic. It includes every salvation that can be given to the waterway. By the four lock, low level, navigation is rightly served; by it a waterway is created of an order befitting the American nation and the world's commercial needs.

CHAPTER XXXIII.

Prototype of High Panama Dams—The Wachusett Failure.

On April 11, 1907, without a warning symptom, a dam-slip little short of a disaster, occurred at the North Dike of the Wachusett Reservoir, of the Metropolitan Water Works, of Boston. At the highest point of the embankment a section some 675 feet long and approximately 100,000 cubic yards in volume subsided and slid from its place into the water, leaving the earth core exposed.

The reservoir dike is of recent construction. It was designed to withstand, at this short section, 65 feet of water. On the date of the collapse it had but 41.7 feet of head, and this was the highest gauge that had ever yet been admitted. The level lacked, therefore, 23.3 feet of the height for which "with unprecedented margin of safety," according to its designer, this embankment was built. In other words, the reservoir was less than two-thirds full, and impounded but half the ultimate contents planned when one-seventh of the crucial volume and section performing the ordinary functions of a dam went down. It subsided and shot out with sufficient momentum to send its rock facing, its gravel, part of the earth ridge and earth core, several hundred feet, in almost a moment. The local journal giving the report says:

"Suddenly there was a rumbling and the noise of huge rocks falling together, and the whole construction of the dike trembled as if shaken by an earthquake.

"When the railroad men appreciated the size of the disaster, and that came quickly, the question of the safety of operating trains over the Central Massachusetts Railroad was raised. A severe vibration it was thought might send down another section of the embankment. The hole that is made in the big bank is a monster, and it is well worth a trip to view what Nature can in a moment do to put at naught the efforts of man." Nature did indeed smite here a few complacencies, when, in the providence of God, before the water reached nearly its destined height, she repudiated thus forcefully the enigneering illusions, and took back her own. Had the reservoir been full and thus all the unstable and fateful mass under the crest been saturated, would anything have diverted from lower Clinton and the valley below the fate of Johnstown? Would they not

have joined Galveston, St. Pierre, San Francisco and Kingston in the growing list of great disasters? The gratulations that weaknesses and faulty designing brought a reckoning to but 675 feet out of the two miles of embankment are as quaintly audacious as they are misleading, since a visit to the locality discloses that THIS SECTION IMMEDIATELY AT THE SAG OR OUTLET OF SANDY POND IS THE ONLY PART OF THE EMBANKMENT WHICH HAD AGAINST IT ANY WATER AT ALL. Except at the sag, the reservoir, less than two-thirds full, made no trial whatsoever in any way or degree of this earth dam, and the water, owing to the natural configuration of the ground, had no more chance for an escape than has the swan boat lake in Central Park. At the sag, however, there was a chance for failure, and here two slides did befall under the partial head.

The smaller or south slip occurred where there was but a few feet of water against the face. This trivial amount, even, was enough to melt the slope like sugar and let the gravel facing and berm slide away. The second break, beginning a couple of hundred feet north of this with a little natural peninsula intervening, extends in a broken curve, half-moon shaped with a nearly vertical cliff-like bank. The chord to the arc is 675 feet long. In the bank standing, back of the cave, there are in two places cracks, and the fall of further small masses is imminent. The subsidence and slip extends the whole width of the sag or outlet of the old pond. Right here was the only place calling for what one would seriously deem a dam. The Lake Reservoir has been lowered about a foot below the critical level since the misfortune. Though being two-thirds full, it shows numerous low islands and knolls. In only two places did the waters even touch the toe of the slope in this work of engineering art, and, except at these two places, the edge of the water is from fifty to several hundred feet distant from it, with stretches of bare, sandy flats, stripped of vegetation, and from two to six feet above water, intervening. The Dike is all, except at the sag, a mere rip-rapped levee. It never elsewhere, even when full, would have had against it more than twenty feet or so of water—half the depth that presses in floods against thousands of miles of levees unknown to fame.

Examining the detailed plans, specifications and works of execution at this reservoir, one notes that they reflect two dominant ideas, one an invention, the other a specialist's concept and exemplification of the Hazen formula, of through and under-

dam percolation, together with unique ideas touching the selection and distribution of materials for earth dams, their slopes and loads.

To the invention per se (a method of setting sheet piling in panels to depths of fifty or sixty feet, where favorable material permits) we record the free and open homage always due to a successful expedient. The sheet-piling is extended, however, not only under the short dip, but under all the rest of the long embankment, which, as was said, will never have more than twenty feet or so of pressure. Equally, across the long plateaus and at the trough of the old pond, a great trench was dug where possible sixty feet deep and the patent sheet piling was driven in the bottom another fifty or sixty feet. If ever the engineers of the Boston water supply should dominate the construction of the levee system on the Mississippi River it would take the National and State treasuries to pay for the thousands of miles of sixty-foot trenches and sheet piling which they would install, for the river dikes have to meet double the head pressing on most of the Wachusett construction.

There was a little gap, however, that at the old pond neck or outlet about 675 feet across. The earth dam here was to hold back water to the depth or head of sixty-five feet. This situation was "met" in a special design and construction, with which its creator was so content that he planned its immortality. He had gone with two other similarly eminent specialists to sit as final judge and jury upon their own so much-challenged plan for Panama. They, of course, reported anew their designs as preeminently safe and certain, though in the same hour the vaunted justification for the Isthmian dams, the Dike, was making public mockery of the pretense. Its highest and only important section, under the advancing saturation, lost cohesion, overbore friction, and while the three engineers were confirming to the Secretary of War their technical pledges and sealing its reembodiments, with a roar it went crashing down into the reservoir. Two authoritative technical journals have published accounts of the failure. Both were of contributions in text, photographs and data from the sources directly interested in minimizing the real importance of the occurrence. The two descriptions are accurate so far as they go, but they are naturally more conspicuous for the sagacity with which they leave things unsaid than for their illuminating comprehensiveness. The import and the relationships of the sinister happening are therefore, of course, quite pardonably ignored. It is considered from

a local viewpoint alone, and no mention is made of its having a bearing upon anything but academic questions of earth dams.

The slide in this Dike, is however, unfortunately, not an isolated misadventure to be casually reviewed, while broken personal prestige rehabilitates itself by virtue of charity and silence. It is a national concern and should be studied as such, for it is related directly and intimately to the expenditure of half a billion dollars. The Wachusett Dike carried the destinies of the Government's Panama Canal. The great Gatun Dam, the central feature of the Isthmian Waterway, was designed upon much more adverse foundations, by the selfsame engineer, from the selfsame model, as was the North Dike of the Clinton Reservoir, and the engineering trustworthiness and actual structure are together there weighed in the balance and found ominously wanting.

Earth dams are as old as Mother Earth herself. They have been built successfully and rightly in every quarter of the globe as long as man has been man, so the naive conclusion that the "dike type of earth dam is not discredited" will probably go undisputed. But nature has certainly repudiated violently this individual design of the earth dam and the quality of discernment, judgment and experience which evolved it.

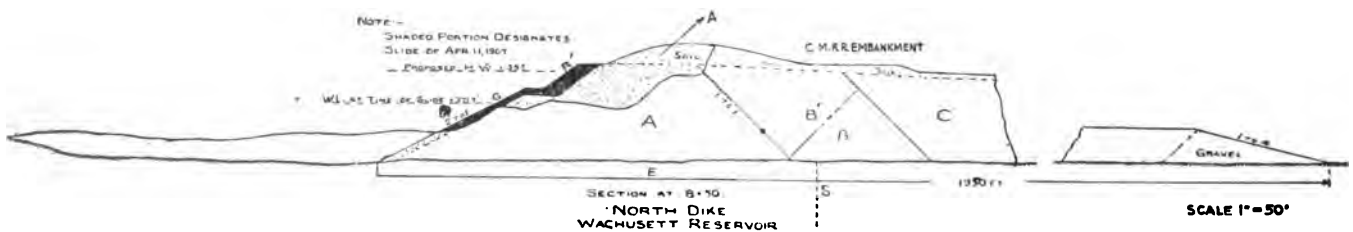
An inspection of Fig. 1 in the illustration shows that the portions A, B, S, C and R are the essential artificial elements. The office of A is the vital one of protecting and supporting the impervious core B, and of carrying the shield of rip-rap against erosion. Page 484.

Since the earth core B lies on the steep rear slope of A, the upper part of B naturally owes its position and integrity almost entirely to A. It is evident that the stability and integrity of A are a sine qua non of the dam. The material of A is derived from the natural earth, and is the same in character except that (E) is consolidated by rain and aeons of time, while A is a recent artificial ridge. The material is a fine, silt-like sand, water and glacier-ground until its dominant particles have had the angularities rounded. It is, when dry, decently reliable in a bank or cut, but when wet it takes on changed characteristics, just as do the Panama soils. These changes must be anticipated and forestalled. Both develop a treacherous, unstable, mushy disposition. Both flow and flatten out, the particles sliding readily over one another, similarly somewhat to their action in quicksand. The Panama soil becomes, in addition, viscous and pasty. So long as there was no water in the Clinton Reservoir

the ridge A stood all right, but as the water rose the lower planes of the mass were successively saturated, the voids filled directly by capillary action. The upper portions were dampened by the melting snows and spring rains. Finally the critical stage and state were reached, friction was overcome through saturation, and somewhere below water level in the lower part of A or in the bottom of E a displacement occurred and the portion A subsided and slid away, carrying the gravel berm and the rip-

rap with a rush into the lake. The full length of the section of the dam against which any water stood and half the crest width went. The upper outer corner of the core B broke off and subsided nearly vertically.

By the favor of chance the reservoir lacked twenty-three feet of being full. Had it been full the entire mass A would have been saturated, and therefore in a critical condition, and the core B, likewise saturated, must have brought some additional weight,



NORTH DIKE
WACHUSETT RESERVOIR

FIG. 1.

making still more for deformation and displacement in the soggy ridge A. The point X at the upper end of the slope line is very close to the ultimate reservoir height, and with a full lake or a few degrees flatter slope to the sodden slide, the dreadful would have happened. Against this danger the mass C afforded no protection whatever, since it would have been overtopped and eroded. Figures 2 and 3 show the cross sections of the Wachusett earth-dam imposed upon those of the Gatun, Sosa, and Corozal dams as now designed. They very graphically show what a very narrow margin corresponding slips to the same slope would leave in the Isthmian structures before they went in water avalanches to the seas.

In the report of the American Society of Civil Engineers, 1907, will be found a valuable paper on earth dams, in which the proposed Gatun construction for Panama and some of the pregnant features are lucidly treated. The designer of the Clinton Works contributed to the discsussion: "The North Dike of the Wachusett Reservoir, and the proposed Gatun dam, with their vast dimensions, seem especially to have disturbed Mr. ——, as he speaks of the Gatun Dam as a 'monster dam design.' The writer as the designer of one of these dams and a participant in the design of the other, etc." This personal avowal of creatorship is quoted because with creatorship goes responsibility.

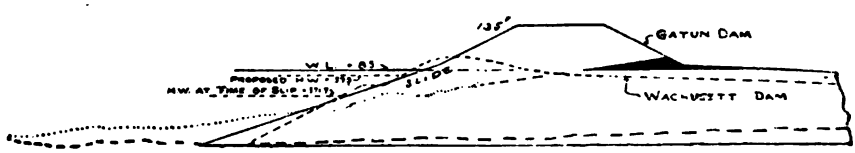
In two instances of gross mistakes in the Panama plans the errors were saddled upon subordinates. Here the authorship of the Wachusett design is formally recorded by the engineer himself. The Gatun Dam for the Panama Canal was proposed by the five Minority members of the International Board. Of the five, two only were supposedly dam specialists, the designer of the Wachusett Dike and one of the designers of the old Bohio Dam. The latter had been the undoing of the former eighty-five-foot project of 1901. It had been proved impracticable when competent investigation was made and had been completely abandoned. The leadership for the Panama dam problems was accorded therefore to the Wachusett specialist. He projected for Panama on both the Atlantic and Pacific sides a series of high earth dams, the Gatun, "the greatest construction ever undertaken by men." They were brought by their mass and by the special character of their alluvial foundations into the realm of experiment utterly, but they were accepted by the four remaining experts, by the Commissioners and the Secretary of War, all because the North Dike of the Wachusett reservoir was deemed

such a convincing and a shining example in new and advanced technique.

Its designer explained his art to the Senate Committee: "In some of the testimony it has been stated that this whole matter was an engineering guess. I wish to say distinctly that this is not, in my opinion, an engineering guess. There has been allowed a factor of safety that is beyond all factors allowed in the past."

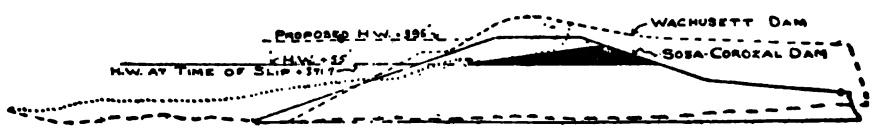
Senator Morgan—"Beyond all precedent?"

Mr. Stearns—"Beyond all precedent, except in the case of this dam which I built, which is the precedent for this particular construction."



GATUN AND WACHUSETT DAMS

FIG. 2.



SOSA-COROZAL AND WACHUSETT DAMS

FIG. 3.

The five experts supporting the Isthmian proposition wrote: "The nearest precedent, in general design, for the Gatun Dam is the North Dike of the Wachusett Reservoir, which at its deepest place will have sixty-five feet against it. The highest portion of this Dike was built on exactly the plan proposed for the Gatun Dam."

The same steep earth-sustained 2 to 1 slope fronts the Gatun Lake, 170 and more square miles in area, deluged in their season by tropic rains and lashed by the Isthmian winds into hungry, eating waves, as fronts the diminutive Metropolitan Reservoir, whose riplets, the local account says, were by good grace not blown toward the open wound of the earth core. The faces of both are protected by the same means—a layer of rip-rap set on the slope of earth. As the mud of the marshes and the silt-jelly of Limon bay are to go into the body and heart of the Gatun

Dam, a sliding cushion for whatever is imposed upon them, so at Wachusett the material of the Dike under even partial saturation has become mud-jelly, which has slid with its rock facing to destruction. The notorious and never-failing characteristic of the saturation of Isthmian earth is that it forms a pasty, sodden, yielding, swallowing mass, whose angle of repose is very flat, six and more to one. Witness the long, ever-moving, half mile, red historic slide, and the other lesser slips at the Culebra; the boggy spoil areas, the mired steam shovels and the glacier-creeping dumps near Pedro Miguel. So we are to have for our World Canal, the duplicate embodiment of a formula based upon homogeneous foundations which nature has not there supplied, and requiring modification accordingly, applied equally to structures to meet any head, no matter how high. No saving appreciation has been disclosed of such controlling factors as a deep lake, against nearly 7,000 feet of front, five times the northern rainfall saturation, or the quiverings due to whirling rushes through lock sluices, and the vibrations of a spillway so planned that it converges in a toboggan fall of 70 feet, the flood escape from Gatun Lake, 700 feet wide and 16 feet deep, into a concrete canyon but 150 feet wide.

Estimating proportionately to weight, volume and length of the exposed embankment, which serves the function of a dam, together with the head of water, which each must withstand, one is brought to contemplate the serious and alarming likelihood, if not certainty, that an accident at the Isthmus commensurate with that of April 11 at the Boston Reservoir, would have ended the career of the Panama Canal. Taking the Massachusetts slide length at 675 feet and the volume at 100,000 cubic yards, and noting that the total length of the Gatun Dam having water against it is over ten times as great, that the exposed slope is over twice as long and the crest 55 feet higher, it becomes apparent from simple mathematics that the equivalent mass at Panama would be over twenty times the amount. Besides these, there is the factor of saturation from twice the head of water, and five times the annual rainfall on a still more treacherous material. From the first two elements alone two or more million cubic yards would be the relative equivalence. Two or more million cubic yards from the Gatun Dam of silt-jelly from Limon Bay or mud of the swamps, or the sliding clays or pasty ashes of Culebra, going down with a crash into Gatun Lake, and leaving the over-topped mass of the earth-fill at the scour of its waters, would mean a mortal disaster for the waterway. It will be

presently seen that the foundation safeguards which were incorporated in the Wachusett Dike were not, according to the latest official testimony, to be embodied in the Isthmian Dam, so that its hazards from this further source are enormously increased. The repair of the very high dams at Panama will be particularly difficult. The Culebra Cut will be finished. Its material will have been transported and deposited into embankments and before more could be supplied, steam shovels and their train system must be installed de novo. The lake depth, 85 feet, is too great to admit of repair, by the quick and effective methods of hydraulic dredges. Yet every minute and second after an accident would be momentous, and the Gatun Dam, if the slope rearward was overtopped, would soon be in the Atlantic Ocean.

The vital and inescapable dangers prepared for the country in this "Monster Gatun design" were clearly set forth and impressed with all the force that the English language allowed by the Majority of the Consulting Engineers, but the public has been mostly unaquainted with their message. This formidable slide of the Wachusett earth dam comes to confirm their prophecies.

With the Metropolitan Dike, and the accident which sent one-seventh of its critical volume to the bottom of the Reservoir, we concern ourselves only as it is the pattern, the model and precursor of its great progeny, the Isthmian Dams.

Before the Investigating Committee of the Senate, the designer of all these structures, detailed the series of laboratory tests with earths from which he demonstrated the different permeabilities, resistances, capillary actions, etc., in materials. Part were made at Lawrence, part at Clinton, Mass. They were conducted with a "galvanized iron tank filled with the sand or other material to be tested, the water being applied at the top and being drawn out at the bottom through a faucet. By opening or closing the faucet, different quantities of water could be made to pass and the difference in amounts of resistance caused by passing through 3 feet was measured." "Another set of tests was made in a tank, a long wooden box 60 feet long and 6 feet wide and 8 feet high." "The next test was in an iron pipe about 10 inches in diameter and I think about 10 feet long." "I built an experimental dike in this large, wooden tank that I spoke of. I am trying to show that this is not an engineering guess." From the laboratory tests the permeability, filtrations, resistances, etc., were figured out and the Dike was built accordingly.

Some interesting tests were evidently conducted for Panama also. His Senate testimony reads: "I had particularly requested in my communication to the Isthmus, sent through the proper parties, of course, that they take a sample of the material pumped up from the boring hole in a pail without letting any spill from the pail. This sample was taken as I requested, and what we saw in the bottom of the pail was sand and fine material mixed with it so that one would say it was practically impervious, and then the last thing that settled in the pail was the fine clay which left a shiny surface over the whole thing, about as you see in the bottom of a mud puddle in the street after a rain, and that makes the bottom of the puddle pretty nearly water-tight. It showed very clearly as a single sample that there was this fine clay in sufficient quantities to make it substantially, if not absolutely, watertight."

A pail of water to determine the permeability of the greatest dam ever projected! This is the engineer who testified as to the means of propelling battleships and merchant vessels through the locks:

Senator Kittridge—How would you push the ship ahead? Would you use a windlass, or what?

Mr. Stearns—Generally it would be by a tug behind it.

A pushing tug, a pail of muddy water, a Bohio Dam, a Wachusett Dike—precious pledges for Gatun and the Panama Canal!

Senator Morgan—It has been stated in the testimony of the dams that failed * * * that this dam on the Mill River failed at a time when the water was four feet below the top and it failed by the sloughing or caving of the lower end of the dam.

Mr. Stearns—It was built in a way that engineers would not build now * * * this slid off. I think the water came through and saturated this material, and it would not stand at that steep angle."

The designer, confirming his elements in the dike of the sixty-foot box, embodied them in the Wachusett embankment, and without waiting for time to sift and test duplicated them in each and every embankment projected to hold up the big deep lakes on the Isthmus. The integrity of the Gatun Dam, with over 30 million tons of earth, holding up Lake Gatun at eighty-five feet and of the Corozal and La Boca Dams with 18 million tons to create and sustain Lake Sosa at sixty-five feet above low tide,

has been assured to the Nation upon the authority of the designer and design of the archetypal Clinton structure of great claims and sorry discomfiture.

The design was repeated in colossal forms, once at Gatun and thrice near Panama. Each and every one is the Wachusett Dike in a *magnificat.*

Almost immediately after the assembling of the "Board of Consulting Engineers," before there had been any time or opportunity to digest the Isthmian data or examine the physical factors and conditions, the author of this construction, a member of the Board, began the pæan and the propaganda to duplicate the Wachusett performance on a grand scale, and make it the central and glorified feature of the Panama Canal. The collective body,

CHAGRES, WHERE GATUN DAM IS PLANNED TO CROSS.

at his invitation, went down to Boston to study this last achievement in engineering. When, however, the Isthmian structure and its allied feature, the lock flights, were proposed they arrayed the two parties of the Board in opposition which divided them fundamentally. The dam, to weigh over 30,000,000 tons, was to be the hugest structure ever attempted in history. It was therefore in that fact alone an experiment with no precedent of

guarantee in time or place. The Majority therefore set themselves squarely upon the first tenet—the Panama Canal should not be an experiment in canal building. "The Board is unqualifiedly of the opinion that no such vast and doubtful experiment should be indulged in, but, on the contrary, that every work of whatever nature should be so designed and built as to include only those features which experience has demonstrated to be positively safe and efficient."

Having thus condemned the principle of adventure and speculation in the great national work, they proceeded to point out the chances against the success of this particular experiment. The foundations at Panama were not of rock but of acknowledged alluvium. In the Gatun Gorges there was a surface stratum of clay, in places but 31 feet thick. Underneath this, extending from 31 down to 204 and 268 feet, the material was pervious, water-soaked and artesian, the discharge rising in the driven tubes from 7 to 18 feet above the river. Not alone was it gambling, it was foolhardy to trust the mass of 21 million cubic yards upon such foundations. The Majority wrote: "The subsurface material at Gatun, extending down to the hard indurated sandy clay or soft rock, attaining a maximum depth of 268 feet, is in large part of a comparatively fine character, consisting of sand and clay in various degrees of mixture, but the borings have also shown coarse sand and gravel, with water flowing through it and out of some of the pipes used in making the examination." And again, "these are disquieting considerations in the designs of dams to retain water of depths varying from thirty to possibly eighty-five feet or more." "The United States Government is proposing to spend many millions of dollars for the construction of this great waterway, which is to serve the commerce of the world for all time, and the very existence of which would depend upon the permanent stability and unquestioned safety of its dams. The Board is therefore of opinion that the existence of such costly facilities for the world's commerce should not depend upon great reservoirs held by earth embankments, resting literally upon mud foundations or those of even sand and gravel." "There are grave reasons for doubting the stability of those types of structures under such circumstances."

Finding the design prepared for the waterway by their Minority Colleagues thus freighted with mischief, they detailed a lock canal plan which they pronounced free from the menacing features and which was recorded as being safe and untainted of the experimental. This design had its summit level not at

85, but at 60 feet. It incorporated a third lake, thus abolishing locks in flight and high dams. The best arrangement enabled the vast Gatun embankment to be superseded by one of a quarter the volume under a 29-foot head. The head being reduced to less than a third eliminated the technical problems. "This plan provides for a summit level of moderate height and for corresponding dams. It would have duplicate locks throughout of one lift only between adjacent levels." (Not flights.)

It is apparent therefore, that a Lock Canal at Panama did not at all necessarily involve the abnormal, perilous or the questionable. The Majority being thus uncompromisingly against the central and pivotal elements of the high level scheme, the five engineers arranged to buttress their Dam by the same measures of foundation-safeguarding that they had incorporated at Wachusett. "In that case (the Boston Reservoir) deep and heavy sheet piling or deep excavation of the natural soil with refilling of suitable material was employed to prevent seepage or percolation, wherever it was apprehended that the nature of the substrata was such as to permit it. It is the judgment of the Board that such safeguarding features as core walls, sheet piling or the removal of unsuitable material should not be omitted in similar structures on this work of extraordinary magnitude and supreme importance."

The Minority five then conceded this. They wrote: "In the construction of the Dam it is proposed to excavate surface material to such an extent that the impervious material of the embankment will come in direct contact with the impervious, clayey material. Also to do any other work required to cut off the flow through any pervious material which further investigations may disclose." They added for this an allowance to be included in the estimate of cost of the dams of $400,000. The Gatun Dam became, therefore, safeguarded in the exact way as had been the Wachusett Dike, so it was supposedly vouched for and guaranteed in the success of its small predecessor.

Soon, however, the five engineers were brought up to the practical question of "How? How?" Then the Panama proposition went off into the air and the Gatun Dam fell summarily out of even the Wachusett class. The pervious strata in the two gorges at Gatun extend to 204 and 268 feet, much below the limits of caisson or sheet piling work. Their width at sea level is roundly 2,700 feet. It became speedily patent that these experts had proposed and stipulated the physically impossible,

since cutting off the water in the deep gorges was the dream of Engineering Quixotes. Before the Senate Committee, therefore, they openly and entirely abandoned the provision thus categorically specified. The Isthmian structure of 30,000,000 tons in weight under an 85-foot head was there acknowledged to be then projected and advocated without the defenses and precautions which had been incorporated to safeguard the small Wachusett Dike, with but 65 feet of head, against some 675 feet alone of its length. Notwithstanding this, they argued speciously

CENTER LINE OF LA BOCA DAM, LOOKING ACROSS RIO GRANDE RIVER FROM SOSA HILL.

and persistently that the Gatun Dam would be quite safe. Why not? They had tested sands and gravel carefully in two laboratories, in tanks and tubes with three feet of material, a faucet and a miniature dike in a box. They had settled the slope, the permeability and all other factors of safety, as the designer averred, "beyond all precedent, except in the case of this dam which I built."

The lock flights complementary to the pernicious high dams were pronounced by the Majority of the Board of Consulting Engineers even more dangerous and objectionable than the dams. It was recorded that they were "perilously near imprac-

ticable for battleships" and extra hazardous for large merchant ships. But the Triumvirs have just reported that the rock (argillaceous sandstone is its latest name) will withstand the concrete lock weights. It has all been tested and proven in another box of sand. They write, "additional tests were made at our request with an improvised apparatus to give a further indication of the ultimate supporting power of the rock. In making these tests irregular pieces of the rock about three inches to ten inches across were bedded in sand in a box resting on scales, so that the top of the pieces would be substantially level; the top was then made smooth and pressure was applied on an area one inch in diameter.

All this teetering of weights as settling the question of lock foundations is quite beside the mark. No one has disputed that the "sandstone," where it exists, is a good and adequate foundation for a lock. But what of the foundations where it does not exist, and the masonry must repose upon the pervious strata? These are the conditions which are impeached. There is no mention of this feature in the "deciding Report." The objections to the lock tiers are not answered or touched by testing the crushing limit of indurated clay. The relation of the lock tiers to navigation, the locating of the lower lock and approaches in a morass, the setting the upper lock to overhang this "argillaceous sandstone," the absence of foundations for the upper approaches, the impracticability of establishing proper safety dams to safeguard the lakes, the inadequate width of the locks to anticipate battleship growth, questions of future lake saturation in the pervious strata under the locks, all these and many allied problems are avoided. This is circumspect. Bohio and Wachusett consort illy with Delphic oracles. Pronouncements are promised upon the Gatun Dam. The country knows just what these will be. Judging the future by the past, the corroboration of former decisions will be complete and unanimous, and it will be announced anew to the world that the Panama dams are safe and certain—like the North Dike of the Wachusett Reservoir.

CHAPTER XXXIV.

Evolution of Canal Plans.

It is in order here to make a very general statement regarding designs for the waterway. The struggles between the two extreme canal types—the sea level and the high level—began in that far day which gave them both birth, the Paris Congress of 1879. There gathered to this Congress one of the largest bodies of technical and scientific men that ever assembled. Delegates were sent from all parts of the civilized globe—ninety-eight men in all. There sat in those sessions Sir John Hawkshaw and Sir Charles Hartley; Derks, constructor of the Amsterdam Canal; Voisin Bey, constructor of the Suez Canal; Waldorf, of the Swiss Canals, and scores of the most prominent engineers then living. Our own Ammen and Selfridge were there, the first, one of the most intense advocates a lock canal has ever had. To the technical sub-committee were submitted, as the Congress record shows, some fourteen projects.

Each of the rival groups analyzed, sifted, eliminated and finally amalgamated from the elements of these fourteen. The canals they respectively recommended were the best that these two parties could evolve out of all the elements and all the plans thus far devised. They were buckling for the first great encounter in this arena of ninety-eight men, and they omitted nothing which could strengthen their hands. They incorporated all the ideas which could give them the mastery. If any feature was declined by its own party it was because, to its best belief, this feature was to the canal, as then planned, not desirable. The two types locked horns in the general session, and the sea level won out. It entered upon its day, but its rival was not dead. The sea level never attained a supremacy so safe that it could lift its foot off the neck of its lock competitor. Commission after commission made through the years a continuous judgment bar. The struggle went on, yet neither quite vanquished the other. Through this fight of over a quarter of a century we may readily believe that each steadily kept its gaze alert for every leverage and for every vantage. It drew from all known old sources and from each new source.

It is rational to believe that at every step of this long way the different guardians of the two types incorporated at the various stages all that they knew and all that they believed best for their chosen order. Out of the struggle came the survival of the fittest, and what stood September 1, 1905, as types for the sea-level and high-lock canals represented the fruitage of all that had gone before. When the Panama Canal came into the hands of our Commissioners, four years ago, still anew, the elements were studied, analyzed, sifted, eliminated and amalgamated. As recently as seven months before the International Board convened a latest report was made reviewing the high level and the sea level up to date. The high level was left unchanged by the Commission, and virtually in its then existing form was submitted to the International Board. The sea level, confirming a last departure, a tunnel, submitted also its latest and, as its official advocates believed, its best evolution.

These two types, therefore, came September 1, 1905, to stand before the technical bar for the death throw.

There entered the International Board in that final struggle another canal design. It was officially introduced by the Commission as the "Project of Mr. Lindon W. Bates, which is interesting on account of its novelty and is therefore laid before you."

It becomes surely legitimate in the face of technical history to inquire what were the elements, the features, the treatments of the two types as submitted to this body. In short, what were the designs when they went into the International Board? What did the "Novel Project" propose?—What were the plans when they came out from the Board?

What are the elements of a Panama Canal? Dam sites and water sites; dams of different types and heights, varying levels, treatments of rivers, methods of control, depth—such and such only. Engineers do not create elements. They can but combine them into designs. The new project had only the same elements as were possessed by every man since 1859. These had been through half a century, shuffled and reshuffled, combined and recombined. At the end of the year 1904 the author combined the elements differently, and applied the world-old principles in a new method.

The Mountain and the Torrent.—Through all the years in which an Isthmian Canal has been planned to link the

sundered oceans, two features have centred the physical obstacles—the mountain of the Culebra and the torrents of the Chagres. The Culebra was a problem of mass chiefly and its subjugation concerned a treasury. The Chagres was a different question. It was ever the technical riddle which engineers studied. Yet to all low-level canals at Panama it was dictator. To the sea level and a two-lock it is the dominant concern, and even an 85-ft. level has to provide it a via sacra.

The sea level introduced September 1st, 1905, was characterized by certain features for Chagres control. It had a tunnel 3½ miles long. The tunnel of de Lessep's engineers, the tunnel defeated and revived so many times had at last won out; it was definitely recommended by the full engineer committee and the then chief engineer, who announced that an available place had been found for it. Its estimate was also included, $8,000,000. This was the advised canal of the last Walker commission; the design had also diversions for 60 miles paralleling the canal. Through these diversions it carried the Chagres waters to one ocean alone—the Atlantic. It had for Upper Chagres regulation a massive, solid dam at Gamboa. So the impounded waters could not be emptied below the tunnel sill and the lake level lowered.

The new project was in treatment of the river radically and fundamentally different. First, it divided the river. Second, it used the canal bed itself, always before avoided, instead of tunnels and diversions. Third, it discharged the Chagres to both oceans in controllable proportions. Fourth, it had at Gamboa, not a solid earth dam, but an under-sluice masonry dam, allowing the lake level to be lowered and giving a normally-empty-basin control. The whole conception of river treatment was as is readily seen, radically and fundamentally revolutionary. This solution is as to authorship undisputed. "Mr. Bates introduces the feature" (page 29). "The Bates divided river."

When the sea level project comes out from the board it has no tunnel. What has become of the $8,000,000 tunnel? Page 45, Board Report, reads: "As a part of the upper Chagres discharge will flow to the Pacific." Having divided the river, the tunnel was, of course, not needed, and it was abandoned. No members of the International Board even went near its site when at Panama.

The new project alone used the canal for the discharge.

This had been heretofore deprecated. The old sea level incorporated diversions overhanging the canal for 60 miles in menace. Is the canal bed utilized anywhere? Page 44, Board report, "but the plans for a sea level canal contemplate a provision which would permit the discharge through the canal prism." "And regulating sluices near the tidal lock on the Pacific side—dividing the flow between the two oceans."

Next, as to the volume of the Chagres and its discharge quantities. "Designed to divide the flow waters of the Chagres entering the canal into two equal portions," and "there will be no current (experience shows that) which would be materially inconvenient to navigation," thus testifies the Majority in the Senate Committee regarding its recommended solution for the Chagres.

Designs for the Gamboa Dam.—A much disputed problem has always been in canal technique the upper Chagres regulation. How did the sea-level proposal of September 1, 1905, achieve this? It had a high lake impounded by a huge solid earth dam at Gamboa. Its lake, therefore, was incapable of being emptied, save in its upper third, and then only by the means of the tunnel. In this full lake the Chagres floods were to be caught and held.

The new Lake design opposed such a system of treatment. It set at Gamboa a low masonry dam with sluices. Through these sluices the water, during normal discharges, was to run off, thus keeping the water lowered to the lowest plane which the conditions admitted. In this basin of the lowest possible level (and normally it would have been empty, except for the silt trap) the excess floods were to be caught and imprisoned, till the subsidence of the flood situation admitted of their gradual discharge. This constituted the last feature enumerated for the new Chagres solution—the normally empty-basin control. The solid earth dam was the September 1st, 1905, solution. What solution came out of the Board?

The type of dam for Gamboa is given on page 44 of the Majority report.

"The Board has therefore assumed that the controlling sluices to be provided in the Gamboa dam may admit the flood waters of the Chagres into the canal prism at the uniform maximum rate of 15,000 cu. ft. per second."

A solid earth dam? No, an under-sluice masonry dam.

"It is seen, therefore, that there would be no practical dif-

ficulty in depressing the surface of the waters in Gamboa Lake between two severe floods sufficiently to receive the entire maximum average forty-eight hour flow of such a phenomenal flood as that of 1879."

So the last feature of the novel conception is taken with the rest. The whole upper Chagres carried through an under-sluice dam at Gamboa, divided near Obispo and reduced to harmless currents, and then borne in the canal itself to the two distant oceans! This is the solution of the floods which comes out of the International Board as the "Majority design" for the Panama Canal.

The riddle of the Sphinx in the Chagres torrents had been answered to the abandonment of the system recommended in varying forms for a quarter of a century, and the adoption and incorporation of the novel design by the Majority of the International experts into their own project.

Were there any further features of change in the Commission projects bringing them into identity with those of the "Lake Canal"? When the sea level and old 85-ft. entered the Board, the Pacific terminal lock sites were for both at "Miraflores," where it is now found by the chief engineer that no suitable foundations exist. The Lake Project set its end lock at Sosa-Ancon. Miraflores was the site heretofore supposed the outermost available for a terminal Pacific lock. The Lake designs repeated the very early principle of a far-seeing engineer of the Isthmus-terminal locks, "the closest possible to the sea." It claimed to have sufficient data to assert that rock foundations existed here, and hence that its contention was incontrovertible.

Shifting the Lock Sites.—Page 25, Board Report, states:

"It early became apparent that additional information was desirable relating particularly to the possible dam and lock sites at Mindi-Gatun and in the vinicity of La Boca. The Board requested the Isthmian Canal Commission to have further examinations made as follows. * * *

Borings were taken across the valley along the lines indicated, and this information was forwarded for consideration to the Board. The borings in the vicinity of Sosa-Ancon Hill, as well as those in the marine section, were given on Pl. VII. They show the practicability of a lock in the Ancon-Sosa saddle and also at the westerly foot of Sosa Hill."

The contentions regarding the Sosa-Ancon lock site being vindicated, the complete Board, both Majority, Minority and Commission, transferred themselves to the designated location. On its foundations thus sustained the Majority

sets its one tide lock and the Minority build their tier of two locks. In introducing a flight where the Lake Project and Sea level both located but single locks, the Government impressed a valuable site into a bad service, for which the rock lengths were quite inadequate. In adopting a good, they perverted it and turned it into an evil.

The Government project, submitted September 1, 1905, gave the canal bottom, at Culebra, a width of 150 ft. and a canal depth of 35 ft. The Lake Project gave a minimum average bottom width in rock of 200 ft. and a depth of 40 ft. In its presentation was inserted a table of ships' growths and a diagram of a 35-ft. canal with an existing Cunarder inserted. The vessel was seen to project beyond the bottom nearly two feet. As recently as seven months before this Board met the sea level committee and the chief engineer had reported their latest design and estimate. It gave a 35-ft. depth, and based its entire design and its new estimate for the canal upon this.

How do the dimensions come from the Board?

(Page 57) "In rock the bottom width was taken at 200 ft." etc.

(Page 56) "The depth of 40 ft. was therefore adopted by the Board as the standard minimum depth in the canal."

Are there changes in other features of either Commission project? The 85-ft. went to the Board with a high dam at Bohio.

The Lake Canal presentation claimed that the position limited the lockage supply and was for a massive high masonry-core dam unfeasible on the revelation of borings (page 13). Yet the projects of the commission through their two years under American study brought in no recommendations except for abandoning Bohio and adopting a sea-level tunnel scheme. Their 85-ft. plan introduced to the experts incorporated the same dam at Bohio and their project went to the Board with this feature.

The Lake Project condemning Bohio, set a dam at Gatun instead—a small dam under a 29-ft. net head.

The Lake design set also a dam at La Boca and a barrage from Ancon Hill to Sosa. Neither official project had any such features. When the Board has reported we read for the Government Minority (p. 77):

"The principal dam is the one at La Boca, which extends from the lock at Sosa Hill, across the mouth of the Rio Grande, to San Juan Hill.

The other dam extends from Sosa Hill to Ancon Hill

and from Ancon Hill in the direction of Corozal to high lands just across the Panama Railroad."

The dams set by the Government upon the new site of Gatun was no longer the low 29-ft. net head alone required, but a stupendous vicious structure quite unprecedented and unwarranted. Again the chance was distorted and was transformed into an evil. The perils created by the needless heights of the other structures, particularly the Corozal dam holding the lake overhanging Panama city have been already detailed.

Salt or Fresh Water Harbor.—One of the fundamental features of the new design was a combination of salt and fresh water harbors at the terminal. The great superiority of such an arrangement in facility and safety and healthfulness for commerce was pointed out at length.

Neither Commission design as submitted September 1, 1905, had combined harbors. How do they emerge from the Board? One finds the Minority in possession now of the combined fresh and salt water harbors.

Terminal Lakes.

Next to the Chagres treatment, the most important feature of the new design was its terminal lakes. The originator of this idea was, it will be remembered, Godin de Lepinay. He formed the conception, he tells us, in 1859, and wrote regarding it to M. Blanchet, then interested in Nicaragua. He brought in a brief report regarding it to one of the technical sub-committees of the Congress of '79. Our American delegates wrote of de Lepinay's proposal: "There were no data whatever." "Absence of surveys, the extent of country entirely unknown, no calculations made to ascertain whether or not the waters of the Chagres in the dry season would be sufficient." "It was to be reached by twelve locks."

Lieutenant Wyse gives in his review a quite different report. He says: "The lake ending at Bohio or Gatun was to be reached by 'six locks.'" Whatever was the proposal to this long gone sub-committee nothing was done, and no committee or commission ever incorporated or advised before a terminal lake. The proposal seems to have just dropped and been buried in the vast volume of the declined in Panama history. The Lake design showed two terminal lakes, the Pacific one, from Sosa-Ancon to Pedro Miguel. the Atlantic starting from Mindi (or Gatun).

Neither Had a Terminal Lake.—This feature was, therefore, as was seen, fundamentally and radically revolutionary also and different from the sea level and high level projects. As the river division had never before in the generation of Isthmian history been incorporated by a committee or commission that had existed, so the terminal lake conception and its inherent possibilities had lain unevoked of them all.

Now both parties, Majority and Minority, adopt them for their lock plans. Their combined acceptance proves this feature to have been extremely valuable for the waterway.

It is seen that every single primary element and treatment of the Lake canal project, from its Atlantic to its Pacific lock, including its complete revolutionary Chagres river solution, is found accepted, adopted and appropriated by one or the other of these Board projects. The Majority incorporated them as submitted in the "Novel Project." The Minority in assimilating them to their pernicious 85-ft. height, turned their boons into banes and made of their salvation but instruments of greater destruction.

This comparison of the "before and after" in the International Board is very useful in view of the recommendation by the Majority of what they consider the best lock canal for Panama.

So much has been said of the 85-ft. plan that the country has been kept quite ignorant of and oblivious to the fact that a four-lock canal at about a 60-ft. summit plane was advised by the International Majority. They indorsed and recommended this at the same time that they condemned in such unqualified terms the 85-ft. scheme with its massive dams "upon inadequate foundations" and its vicious lock tiers. The plan which they recommended as the best lock design at Panama was the Lake Canal.

The Lake Canal project and the recommended Majority lock project are submitted. They are seen to be identical.

Board Report, p. 25, Project IV.

	Board Lock + 60 Ft.	Bates Project.
First lock	Gatun	Brochure 1, Page Pl. IV., Mindi or Gatun.
Lift first lock	80 feet	27 to 33.5 feet.
First dam	Gatun	Mindi first choice, Gatun second choice.
Second lock	Bohio	Gatun first choice, Bohio second choice.

Second dam	Bohio	Gatun first choice, Bohio second choice.
Head first dam	30 feet mean	27 to 33.5 feet.
Head second dam	30 feet mean	29 to 31 feet net.
Type first dam	Undersluice and earth	Undersluice and earth.
Type second dam	Undersluice and earth	Undersluice and earth.
Gamboa dam	Masonry concrete	Masonry concrete.
Gamboa dam type	Undersluice	Undersluice.
Third lock	Pedro Miguel	Pedro Miguel.
Summit level	60 feet	60 to 65, preference 62.5.
Fourth lock	Sosa (west side, but east preferred)	Sosa (east or west side east preferred).
Spillway and lock	Separated	Together preferred, separate admitted.
La Boca Dam	Same	Same.
Sosa lock	26 to 35.5 ft. lift	26 to 35.5 feet lift.
Panama Lake	26.5 feet	26.5 feet.
Alignment	Identical (Mindi to Panama Islands)	Identical (variant to avoid San Juan Reef).
Usable length locks	1,000 feet	1,000 feet.
Depth	40 feet	40 feet.

The Three-Lake Canal is thus fully supported and recommended by the Majority of the International Board as the best lock design for Panama, and the 85-ft. plan is deprecated.

The Minority or 85-ft. sponsors, themselves, supported by the Commission and Secretary of War concede to the mid-level canal the following:

Advantages of the Three-Lake Project.—The advantages of this project are:

"The smaller head of water to be sustained by the dams than by the Gatun dam in the 85-ft. project.

The smaller height of embankment required to maintain the intermediate level, the water surface being 28 ft. lower.

The summit level would be lower and the locks reduced in number from six to four.

There being no flights of two or more locks, but only a single lift at each locality, a transformation to a sea level could be effected more readily.

The great lake to be formed by the Gamboa dam would afford control of the floods of the Chagres with less fluctuations of water in the canal."

In this list of concessions every single principle which has been contended for the new Canal is supported. It is seen, therefore, that its plan has been recommended in toto by the Majority and supported by the Minority, Commission and Secretary of War in all its principles. No official design whatsoever of either party before the American people is so entrenched in expert indorsement, if that be gauge of any value, as is the Lake Canal.

CHAPTER XXXV.

The Panama Railroad.

On May 14, 1904, there was formally transferred to the United States forty-eight miles of railway, twenty-four obsolete locomotives, twenty-four passenger cars, a miscellany of freight cars, three wooden wharves, the La Boca pier, some station buildings and one hundred and odd others from which a precarious revenue was raised, and much jungle real estate. Not a very imposing acquisition one might say, unconsidering. Yet this one short railroad was and may be for ten or a dozen years perhaps the most potentially important trade key in the whole world. Until the canal is built, it and the Tehauntepec line are real dominating factors of the Pacific freight situation. With water transportation on either ocean, the short rail portage has the power to route freight and rule rates on a lion's share of south and mid-Pacific traffic, which is within the grasp of the owners of the Panama and Tehauntepec Railroads. One belongs to the United States, the other to Mexico. National rate regulation has been held as the only way to preserve American freedom of commerce at home. The power has been demanded of Congress to fix the tariffs on the thousands of miles of lines in the United States, infinite in their complexities. Those who have insistently craved this vast new power have held for the American people since March 4, 1904, the ownership, absolute and unchallenged, of a line that can bring every Pacific bund to terms. What has been the history of the new proprietorship of the Panama Railroad, the Government's experiment station in public ownership?

Trustees Refuse to Open the Door.—Has the record been that the trade incubus has been lifted? Has the experience been one of cleaning the rust of thirty years? Have the trustees of the nation's trade opened the door to which they were given the key? The recital of the facts will reveal. Times are changed. The west and the Pacific coast now fully support the transcontinental railways with a vast local business, but it was not always so.

The pioneer railroad group, fighting for fame, fortune and dominion, led by the Sir Francis Drakes of our railway history, swarmed aboard this Isthmian rival thirty years ago. "Their bones are dust, their good swords rust," but

their policy has never died. In the old days the Union and Central Pacific Railroads jointly leased space on the vessels of the Pacific Mail Steamship Company, whose directorate then was railroad-controlled.

The Overland Pool paid its monthly assessment, first of $90,000, then of $100,000; the Steamship Company delivered the goods as specified and rates were made such that high class freight was thrown to the railroads. A limited number of ships were run, no vessels were to be loaded to full capacity. Old ships, small ships, poor ships were kept in service like bob-tailed horse cars to hold a franchise. It was a most clean-cut arrangement in restraint of trade, and to dictate the routing of freight. The wings of the snared were not only clipped, but cut off.

Five years before the first Pacific Mail Pool, one of the most dramatic figures of the financial world had gone to his Waterloo at Panama—Alden B. Stockwell. A new era in the road's history had been marked by the advent of this financial soldier of fortune. He became Commodore Stockwell, sucessor to Russell Sage as President and autocrat of the then great Pacific Mail Steamship Company. He, too, dreamed the century-old dream of the power that lay in Panama's potentiality as a trade route to the east. To the Pacific Mail Steamship Company, of which he had grasped control at a time when its ownership was in feeble hands, he had added the small Pacific Steamer Line of the Panama Railroad. The sea link was then his. He reached out for the railroad, mortgaging to secure its stock, the Howe Sewing Machine, his wife's dower. He then had the land link. With nine directors in each company he strove to bind them firmly together and dictated that far-reaching contract by which the Panama Railroad pledged never in the future to interest itself in Pacific steamer business.

In the Grip of a 15-Year Contract.—To this initial shackle, the Pacific Mail added in 1875 the final fetter. In a fifteen-year contract between the Pacific Mail Steamship Company and the Panama Railroad, the latter surrendered the exclusive right to issue through bills of lading across the Isthmus. Thus at length the circle toward which the overland railroads had been working was completed. They dominated the Pacific Mail, fixing its rates and regulating the carriage of freight and passengers; the Pacific Mail in its turn held the Panama Railroad in the grip of an exclusive contract.

So with the only competitor safely tied up for fifteen years, the pioneers rested upon their labors, in the year 1878, in the consciousness that theirs was the transportation business of the coast safe from all attack.

Through the years of the French Canal Company's assault on the rocky ridges of Culebra, with changed ownership, with alien policies, it was still only the trade blight of the contract that strangled Isthmian trade. For all the coasts north of Panama, the Pacific Mail and the transcontinental railroads adjusted the amount of traffic to be allowed. They arranged the Central American tariffs so that it was as cheap to carry coffee around the continent through the Straits of Magellan. They fixed American rates so that the transcontinental lines favored already in the elements of time and insurance could secure practically all the business.

Such details as the $12 a ton rate to Yokohama, 4,900 miles, and $18 to Panama, 3,260 miles, speak more plainly than any comment. From San Francisco to New York, the fare was $90. From San Francisco to Panama, half way, the fare was $100. The same principle holds still in the hands of the Government managers. In order to prevent economically minded persons from buying a ticket to New York and saving 10 per cent on their jaunt to Panama, the company checked all baggage through to New York and would not give it up at any point between.

Feeding the Southern Pacific.—Often vessels made their trips with unfilled holds, at a time when the freight traffic overland was at its highest. Ship after ship passed the port of San Diego. Not one would stop to take or deliver a pound of freight. All must go to the railroad terminus at San Francisco. The Pacific Mail brought to the Isthmian Railroad no more, in some years, than 13,000 tons of San Francisco freight. Coffee was shipped to New York via San Francisco, New Orleans and the Morgan line, going several thousand miles out of the direct route in order to feed freight to the Southern Pacific.

The report of the Congressional Investigating Committee of 1893, of which Judge T. J. Geary was a member, he whose personal force and fairness later made the Texas Commission law, summed up in its report:

"After the passage of the Interstate Commerce law had compelled the dissolution of the so-called "pool," a transcontinental association was formed, which under some name or other is still in existence, and down to the present time

the Pacific Mail, subsidized by the Government in a large amount each year, has been allowing the transcontinental railway to fix the rates and limit the traffic over its lines. These two contracts were so far practically parts of one and the same that the amount paid the Panama Railroad monthly was fixed with regard to that paid to the Pacific Mail by the transcontinental roads, and when the latter was lowered from $90,000 a month to $75,000 the former was lowered from $75,000 to $55,000. The object is frankly stated by the officers of both the transcontinental roads and the Pacific Mail. It was to maintain rates above the level to which they would fall if free competition between these several routes had continued. It seems to be certain that a very large, if not an absolutely controlling interest, in the stock and directory of the Pacific Mail Company is owned by individuals and estates very largely interested in the stock and directories of the transcontinental roads; and it is proven that the same individuals composing a majority of the directory of the Pacific Mail composed a majority of the directors present at the meeting of the Panama Railroad Company's directory at which the contract between the Pacific Mail and the railroad company of February 1, 1878, was ratified and executed.

Your committee cannot refrain from calling attention to what seems to be an obvious deduction from the facts shown; that it is the interest of the United States that the American people should absolutely control some outlet across the Isthmus, at some point which shall be used for the benefit of American trade in general as an open and continuous competitor, affording no opportunity for entangling subsidies, from the general competing lines, or chance of falling into the grasp of any monopoly through stock manipulation."

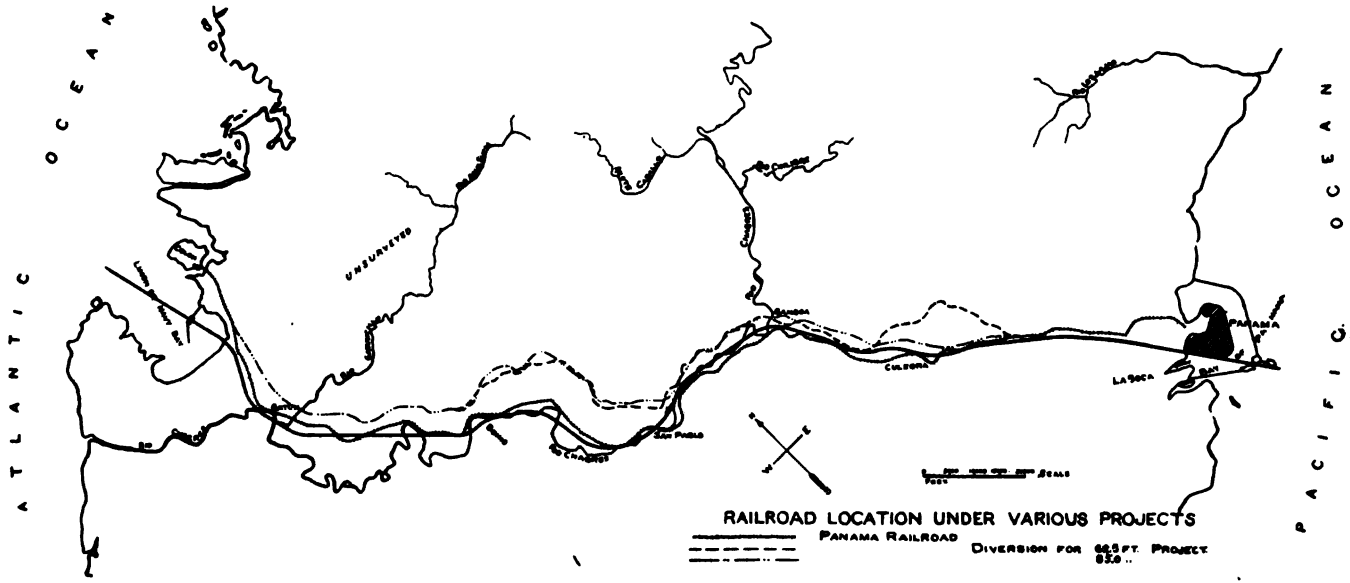
It is old history, but enlightening.

With this sinister story behind, how significant are now the actions of our representatives when they do actually control this vital outlet across the Isthmus. Go right to the heart of the old trade treaty, the Pacific Mail Pool; how has this been dealt with?

The Isthmus is crossed by forty-eight miles of railroad, with a harbor at each terminus, permitting full access to ocean traffic. Steamers take but five days from New York to Colon, and some twelve days from Panama to San Francisco. Until the canal is opened the Panama line can control, to a large measure, the non-perishable freight trade of the Pacific north and south.

Mr. Richard L. Walker, traffic manager of this road, testified before the House Committee of the last Congress, page 185, Investigations of Panama Railways:

Mr. Mann—If we should, in addition to that, put a line



MAP SHOWING RAILWAY LOCATION UNDER VARIOUS PROJECTS.

on the Pacific, would we get more business at a low rate or would we lose business by losing the Pacific Mail line?

Mr. Walker—If you put a line on the Pacific and run it regularly you can wipe the transcontinental lines off the face of the United States.

This is rather a sweeping assertion, but significant.

In figuring the tonnage that would have passed the canal had it existed in 1890, the Isthmian Canal Commission estimated as follows:

Possible Commerce Under Liberal Policy.—"A detailed study has been made to ascertain the tons of cargo or freight and the net registered tonnage of the vessels that might have passed through an Isthmian canal had one been in existence. The cargo tonnage was found to amount to 6,702,541."

There actually crossed by the Panama Railroad in 1899, 287,400 tons of 2,000 pounds, or 40 cu. ft.—192,598 net canal registry tons. In 1906 the movement was but 288,651 short tons, practically the same as in 1899. Now, there is no mysterious attraction in a canal. If it be as cheap to send goods by an Isthmian railway as by an Isthmian canal, the goods will utilize the railway; they need not wait for a canal's completion. Transfer risks are all reducible to terms of money by insurance companies. It is a logical conclusion that much of this tonnage is potentially available for an Isthmian railroad—

1.—If the freight rate, including insurance and all the allied costs of transfer, be made commensurate with the canal tolls.

2.—If the steamship co-carriers are not handed out by the Government such rights that they can restrain trade.

The railroad policy and its management are of the greatest concern to the canal, which it parallels, and to the construction of which it is a necessary mechanism. Beyond this immediate and practical importance to the waterway itself, there is a further vital consideration of national integrity. The Government has set itself the task of regulating in their myriad complexities the thousands of miles of railways through the States. In undertaking this the call is urgent and the need for the cleanest and most impartial national supervision is vital. But how can the Federal Government be trusted to maintain a fair control and relationship in this great matter, so complicated by property and rights and so interwoven and enmeshed with influence and vested interests, if it cannot or does not utilize the

potentialities of a 48-mile road owned by the people? If the railroads are on trial in the states the Government is on trial at Panama in this great pregnant question of common carrier justice.

The National Freight Pool.—The Pacific Mail Steamship Company, a subsidiary organization to the Southern Pacific Railway Company, fixes all rates eastbound, and divides receipts with the Panama Railroad Company, Government owned. Of these each gets a percentage.

The rate on every ton of freight originating on the whole Pacific Coast of the United States which might utilize the Ishmian route is thus adjusted. The old control is so retained. This is the "harmony" which the Secretary of War proclaims.

The provisions which gave the old contract its clutch on commerce across the Isthmus were two. The first was the pooling of the freight and passenger receipts.

It is agreed that through freight rates, so far as the same accrue to the Railroad Company and Steamship Company, shall be divided between them as follows:

On freight between United States Atlantic coast ports and United States Pacific coast ports:

To the Railroad Company, 50%.

To the Steamship Company, 50%.

Minimum rate, 40 cts. per hundred pounds or 10 cts. per cu. ft.

The second was the provision that the initial carrier should fix the rates.

Subject to the above agreed minima, the freight rates are to be fixed by the initial carriers.

This arrangement is still in force under a sort of "modus vivendi." The report of the Isthmian Canal Commission states:

"The Pacific Mail Steamship Company continues the company's only co-carrier in traffic originating at and destined to points on the Pacific coast north of Panama, notwithstanding this company has advertised open rates and announced its willingness to enter into traffic relations with any established line with regular sailings to and from the terminals at Panama and Colon."

Tramp Steamer Competition Eliminated.—Lest there should be any real competition it is carefully provided that only regular lines shall be recognized, thus excluding the one main agent that keeps the ocean free of monopoly—the independent steamer. Whoever drafted this provision knew well that in the face of the vested interests of the

Pacific Mail all along the coast no competitive line would be established, while tramp steamers would carry wherever a cargo lay. So they were barred.

While the contract itself is abrogated and the situation exists only because those in power suffer it, there is a certain interest in noting some of the provisions of the "gentlemen's arrangement" in restraint of trade to which the Government is a party. This contract, void under American law, was enforced under the Secretary of War from March 22, 1904, until July 12, 1905. Its provisions were strikingly brought out in the Investigating Report.

Question. Under the traffic contract with the Pacific Mail Steamship Company, who fixes the special rates to be charged from New York to San Francisco, and from San Francisco to New York?

Answer. The Pacific Mail Steamship Company, as the initial carrier, fixes any special rates from San Francisco to New York. The Panama Railroad Company, as the initial carrier, fixes the special rates to be charged from New York to San Francisco. Each initial carrier is limited so that no rate can be less than 40 cts. per 100 lbs. without consultation with the other.

The restraint of trade is clearly shown on page 204 in the text of the contract, whose body is broken, but whose spirit lives by grace of the Secretary of War:

"During the term of this contract the Railroad Company shall protect the interests of the Steamship Company in all traffic north of Panama in connection with said railroad and its Atlantic connecting lines, and especially against all forms of competition whatsoever, and will (so far as it is practicable) give, turn over to and direct to the vessels of the Steamship Company, to the extent that it can lawfully control or influence the same, all business destined to Pacific points north of Panama, originating on the Isthmus of Panama and carried upon its railroad, or which may be sent to the Isthmus of Panama and carried by its own ships or by other ships or lines."

For a time after the Government's acquirement of the Panama Railroad a perfect flood of petitions and memorials poured in praying for the dissolution of its contracts with the various Pacific steamship companies, but lately it has been recognized that nothing which was hoped or expected would be in fact granted; and that the corporate entity of the Panama Railway would be sedulously preserved in order that those things might be done for which direct Congressional sanction could never be obtained.

The report of the Isthmian Canal Commission reads:

"Full authority has been placed in the hands of all co-carriers to fix competitive rates low enough at points of origin to secure business, an agreed percentage of such through rates to accrue to this company."

Discrimination Against United States.—In other words, the Government managers of the Panama Railroad have handed over to alien steamship companies the right to fix rates on all goods of which they are initial carriers. The initial carriers on all west coast South American goods are foreign lines, which for years have discriminated against American goods and are understood to have made no recent change in this policy.

This discrimination is apparent from the following extracts from an official report, showing the rates made to Europe and to America by these lines:

From Guayaquil the rate made by the steamer line for a ton of coffee is $17 to the United States, $15 to Europe. From Payta the rate for hides to New York is $30 and to Europe $20. From Payta the rate on Peruvian bark is $45 to New York, $30 to Europe. (Page 33.)

From Guayaquil to New York on hides $22.50, to Europe $17. (Page 257.) From Guayaquil to New York on cocoa $17, to Europe $15.

Under the contracts which the Panama Railroad Company has with the South American lines, the initial carrier fixes the rate, so that it will be observed that the rate from New York to Payta, which is fixed by the Panama Railroad, is lower than that from Europe on the same class of merchandise, while the rates from Payta, which are fixed by the South American lines, are about 50% higher to New York than to Europe.

The rate on general merchandise from New York to Valparaiso, the principal port of Chili, is $11.20 a ton, while that from Valparaiso to New York is $30 a ton. The rate from New York to Valparaiso is fixed by the Panama Railroad Company, while that from Valparaiso to New York is fixed by the South American lines. The Compania Sud-American de Vapores, one of the contracting South American companies, is a Chilian line subsidized by the Chilian Government.

That the authorities have been in full cognizance of the situation is apparent from the following formal protest, of which extracts are given:

Protest of South American Republics.—To the Honorable William H. Taft, Secretary of War: Mr. Secretary.—The Isthmus of Panama has offered two great obstacles to the exchange of products between the eastern coast of the United States and the Latin-American countries, which we have the honor to represent, and which countries carry on their commerce on the coast of the Pacific. Of these two

obstacles one is physical, being the land which separates the two oceans; the other is artificial, and has been produced, as much by the monopoly which the railroad line from Colon to Panama has had and still enjoys, as by the monopolies which that same railroad company has created for the navigation between Colon and New York and between Panama and the western coast of North and South America.

The American Government is now absolute owner of that railroad and of the steamers which ply between Colon and New York. We are informed by the press that Your Excellency must decide very shortly the manner in which that railroad and those steamers are to be administered, and we hasten, for that reason, to invite Your Excellency's attention to the end that no measure can be adopted which will be more effective in making closer the commercial relations of all our countries with the United States than the systematizing of the transit on the Isthmus upon equitable and liberal basis.

The first evil consequence of the monopolies has been the high tariff rates, which we may call almost prohibitory, and which have diverted the commercial current toward Europe. Some data which we give below prove this assertion:

The nitrate of Chile cannot be brought via Panama. The combined tariff rates between the railroad company and the trust of the steamers of the Southern Pacific coast fix a freight of 47 shillings sterling a ton. That same nitrate reaches New York by steamers via Magellan, paying 23 shillings sterling a ton.

The Peruvian sugar pays by the Isthmus 30 shillings sterling a ton, and 23 shillings sterling a ton via Magellan.

The cocoa of Guayaquil, Panama, pays to Europe from 52 to 58 shillings sterling a ton, and for New York 65 to 68 shillings sterling a ton.

Coffee is exported from Central America to Europe, via Magellan, cheaper than by way of Panama.

The metals of Bolivia, especially tin, cannot be brought to the United States via Panama.

Frequently the case arises that products from our coasts are imported into the United States, after being transshipped either in Liverpool, Havre, or Hamburg, because of the lower freight rates for Europe as against the United States.

It may be calculated that the most distant ports of our respective Republics, are from New York 4,500 miles, via Panama. From these same ports to New York there is a distance of over 11,000 miles, via Magellan, and nevertheless the transportation by this last route, and the transportation by steamer from our ports to Europe, is on an average from 25 to 30% cheaper than our commerce with New York, via Panama.

So that Your Excellency may perceive that the injustice

of the high freight rates is found in the railroad tariff rates, it will suffice to know that from the freight of the 4,500 miles between the extreme ports and New York the Panama Railroad Company takes for itself the 33% for the 46 miles of transit.

Although the navigation companies on the Pacific do not belong to the Panama Railroad Company, this company has arranged matters so that the northern coast may be exclusively served by the Pacific Mail Steamship Company, and the southern coast by two steamship companies formed into a trust, viz.: The Pacific Steam Navigation Company and the South American Steamship Company.

These lines, as a matter of course, take advantage of this privilege to exact as high rates as possible.

The working of this monopoly is very plain. The Panama Railroad Company grants transit facilities only to the combined companies above referred to, while it hinders and closes all doors to other ships outside of the combination arriving at Colon or Panama.

With sentiments of the most distinguished consideration, we subscribe ourselves,

J. B. Calvo, Minister of Costa Rica.
Luis F. Corea, Minister of Nicaragua.
Manuel Alvarez Calderon, Minister of Peru.
Joaquin Walker-Martinez, Minister of Chile.
Ignacio Calderon, Minister of Bolivia.
Jorge Munoz, Minister of Guatemala.
Serafin S. Wither, Charge d'Affaires of Ecuador.

Pooling Arrangement Continues.—The answer to these various governments was extremely courteous, but what has been done? It may be that the contracts in restraint of trade have been in form ended, as has the Pacific Mail contract. It cannot be found out for certain, and has not been announced. All the information on this in our possession indicates that these contracts with the South American lines are still retained in form or spirit. But the form of contract is of small importance beside the living fact that the United States Government lets these foreign lines, discriminating against the American people, fix the rates, and that it continues in a pooling arrangement to divide receipts with them.

In case there is any interest in the text of these contracts, which, to the best of our information, remain in full force, some of the provisions are given.

Copy of agreement between the Panama Railroad Company and the Compania Sud-Americana de Vapores, dated September 10, 1902:

"During the terms of this contract the Railroad Company shall promote and protect the interests of the Steamship

Company in all traffic south of Panama. Especially against all forms of competition whatsoever, and will (so far as it is practicable, and except as hereinafter provided) give, turn over and direct to the vessels of the Steamship Company, as far as it can lawfully control or influence the same, all business destined to Pacific points south of Panama, originating on the Isthmus of Panama, and carried on its railroad, or which may be brought to said Isthmus by its own ships or by other ships or lines.

Rates of freight are to be fixed by the initial carriers on both sides of the Isthmus, subject to the right of revision by the Railroad Company, to the end that one carrier may not maintain reduced rates in connection with the railroad, in competition with another carrier also connecting with the railroad."

Overcapitalization of Panama Railroad.—On November 6, 1902, the United States recognized the independence of Panama. In February our Senate ratified a treaty with the republic. On May 4, 1904, the possessions of the New Panama Canal Company were formally transferred to the United States. In the price of $40,000,000 paid $6,800,000 was allotted as the pro rata value of the railroad. At last the power had come into the hands of the representatives of the American people to lift the incubus of the Isthmus. The power had come and surely the time had come. The rot of thirty years, the abuses of the old ownership, the coercions and discriminations—these were supposedly to be all swept aside under the rule of the United States. High principled, energetic men were going to grasp the throttle of Isthmian affairs. A new era was to open with America clearing the way to the glorious freedom of Pacific commerce. Thus was the policy of justifying means by ends to receive warrant.

It may seem ungenerous at this time to count the cost, but it is nevertheless interesting to figure the capital represented by the Government investment and assumed obligations. First, there is the original price of the property: $6,800,000 was the portion of the sum paid the French, which was assigned to the railroad stock, or deducting the value of the steamers, $6,532,581. Eighty-four thousand and three hundred dollars was paid for the purchase at par of other shares, and for the final 270 shares $72,120 was paid to one of the old railway group. So much for the direct primary expenditure. But there were outstanding 4½% bonds to the value of $2,372,000. On all other moneys which the Government borrows the usual interest is 2%, so these bonds actually represent for it an investment to the amount of $5,337,-

000. Furthermore, there must be returned yearly $225,000 to amortize and pay interest on subsidary bonds, the aftermath of an advance to an embarrassed Colombian dictator. This represents the interest on $11,250,000 at Government rates. Nine years from the treaty date this subsidy annuity originating with the railway concession becomes $250,000 or the interest of $12,500,000. Therefore, the business investment of the United States in the railroad proper is $23,276,001. To this must be added the expenses of double-tracking and prospective changes which will make the business investment $30,000,000.

More Money-Draining Bonds.—With such a condition as this confronting them a first duty of the Americans was to call in the money draining bonds, which was possible at any time on payment of a premium of but half one per cent over the annual interest, and to put the whole matter on a Governmental basis, in harmony with other national institutions.

Instead of retiring the bonds the representatives of the commonwealth issue more bonds—$265,000 for repairs to two of the company's steamers almost as soon as the title was passed to the United States. One cannot but ask why these "repairs" were not paid out of the $560,000 distributed just previous to this bond issue as an 8% dividend, which went to the "French Company" after the actual sale, or why, some of what went to the 5% dividend of the succeeding year's business was not used rather than increase the Government debt. Instead, on top of this, still more bonds—$628,000 was sold as recently as November, 1905, and the money loaned to the Isthmian Canal Commission, then hastily purchased back from the banker who took them. A new dividend of $350,000 was returned to the national coffers in 1905. So the Government through this railroad continues to pay twice its usual rate of interest on one of the most outrageously over-capitalized enterprises on this hemisphere. And this last Congress sanctions advances and orders a million 4% railway bonds to cover them! A table of earnings is instructive:

Statistics.

	Earning Power of Railroad by F. W. Mundy, Page 45. Average of 120 U. S. Railroads Per Mile.	Panama Railroad (see page 426, Isthmian Canal Comm.) to October 1st, 1905. Dividing Totals by 50 Miles.
Gross earnings	10.101	38,251
Operating expenses	6.764	24,272
Net earnings	3.337	13,978
Fixed charges	2,124	6,417

This is four times the earnings, four times the cost of operation, four times the net earnings of the United States mileage.

Abuses at Panama and questionable transactions have come through, or have been concealed by, the policy of running a Government work through a corporation.

Contracts Let Without Competitive Bidding.—1.—Contracts essentially of the canal have been and continue to be let without competitive biddings, as railway concerns. (Investigation of Panama Railroad, page 4.)

In the course of the hearings it developed that during the first six months after the Government took charge of the canal property the Canal Commission directed the officers of the railroad company to purchase supplies for the Commission. Requisitions for such supplies were made. No public advertisement for such supplies was made nor any given. These purchases amounted to about $233,000. These purchases were said to have been made on emergency orders, but the evidence discloses that a very large portion of such supplies were not actually needed at the time of the purchase and have not yet been used. In fact, supplies were received in such quantities, and so much more rapidly than needed that the terminal facilities of the railroad were inadequate to care for them, and some of them had to be rehandled and reshipped at extra expense to the Government.

Questionable Dividend to French Company.—2.—Dividend of 8% to French stockholders is of record as voted after the United States bargained for the property. (General Davis's report, page 5.)

The annual report for 1903 gives the net income of the railroad and steamships at $401,068, yet the road paid an 8% dividend, or the sum of $560,000, while in 1902 the net income was $295,384, and the dividend paid was $280,000.

But for the circumstances that the payment of the last dividend went to the credit of the French Canal Company, that had already bargained to sell its property to the United States, and that the Board simply did the bidding of the company, it is probable that the dividend of the company would not have exceeded its net earnings for the year.

Unnecessary Bond Issue.—3.—Issue of 4½% bonds to make up for deficiency so caused, thus saddling the Government's property with an increased debt, paying over twice the usual Government interest rate. (Investigation of Panama Railroad, pages 25 and 28.)

Mr. Cromwell: There were sold out of the treasury bonds $265,000 in October, 1904, at a premium, viz., at 104½% and interest.

The Chairman: There are $4,191,929.91 of accumulated

earnings. Was not there a sufficient amount of that available to pay for the repairs to the ships?

Mr. Cromwell: Oh yes, certainly.

The Chairman: That is the point.

Mr. Cromwell: Sufficient of that amount was in point of fact physically available in cash, but not necessarily applicable to that purpose. The proper thing was to dispose of the bonds created for that purpose.

The Chairman: To go further in debt rather than use the money you had?

In his supplemental report in 1904 General George Davis wrote of this transaction:

"The statement has been published recently to the effect that it has been found to be necessary to increase the bonded indebtedness of the railroad by the sum of $250,000, the funds used to pay for steamship repairs ordered before the last dividend was paid, so an increased debt has followed payment of last dividend.

The directors of the Panama railroad and the attorney for the same are no doubt able to show, to their own satisfaction at all events, that the course being pursued is exactly the course that should be pursued, and that as a result of the policy the United States is a large beneficiary, but, according to the view of the writer of this report, under the present conditions the position taken by the directorate is wrong in principle as contrary to sound public policy."

Markel Commissary Contract.—4.—Letter of unsuccessful bidder to the President. (Senate Investigation.)

New York, Sept. 7, 1905.—That was the day, I think, that you let this Markel contract.

Mr. Shonts: September 7—Well, the contract will show. I am not sure; I think it was the 6th or 7th.

Senator Taliaferro (reading): "The President, Oyster Bay, L. I.: In the public interest, we earnestly appeal to you to direct the chairman of the Isthmian Canal Commission to withhold the award to J. E. Markel of Omaha, Neb., of certain concessions for conducting hotels, boarding camps and commissary stores on the Isthmus of Panama. These concessions are the most important of the kind ever granted by the United States government, involving a business which, it is estimated, will aggregate the enormous total of $50,000,000 for the term of the contract.

Circumstances connected with the awarding of this privilege seem to indicate collusion, one entire section of our bid having, as we discovered by examination yesterday, been credited to Mr. Markel as an original production, while the precipitancy with which bids were called for, without public advertisement and with no regular time set for receiving and opening said bids in the presence of the bidders, warrants us in the assumption that a predisposition existed to award the contract to Mr. Markel, and that other considerations were sacrificed to this end.

In placing this matter before you, Mr. President, we specifically waive any claim to the Panama concession. Our only desire now is to prevent the consummation of what we deem an irregular proceeding, and in furtherance of this purpose we have, by advice of counsel, formally withdrawn our bid in a letter to Chairman Shonts. Respectfully,

Hudgins & Dumas.

Reply of Mr. Shonts. (Senate Investigation.)

"As soon as the specifications were drafted we mailed to Mr. Markel, to Hudgins & Dumas and to Mr. Balfe each a copy in the same form, and invited proposals. We did not advertise because it was a *railroad matter,* and because of the urgency of the case. I have had several cablegrams from Mr. Stevens since my return, asking me to expedite the arrangement, as existing conditions were very bad."

Mr. Stevens's protest. (Report of the Isthmian Canal Commission.)

"On my arrival in New York, the 22d, there were some very disquieting cablegrams there from the Isthmus—one from Mr. Stevens, who seriously objected to the contract. He made statements that it was a well known fact on the Isthmus that if that contract was carried out it meant a profit to the contractor of a million dollars a year, and some other statements—I don't just remember what the cablegram was."

Letter of Mr. Shonts to Senator J. H. Millard re. Mr. Stevens's protest against the Markel contract. (Senate Investigation.)

February 26, 1906.—My Dear Senator: I have your letter in which you also request that you be furnished with a copy of a cablegram from Chief Engineer Stevens, "stating that in his opinion the prospective profits to Mr. J. E. Markel from a contract which he had entered into with your commission would amount to something like $1,000,000 a year."

Mr. Stevens did send me a cablegram, setting forth for my information his personal views on this subject, in which he did express the opinion that the contract would afford Markel an excessive profit. It very soon developed, however, that the many factors entering into this matter made it clear that only the future could tell the outcome of this contract.

The cable in question, being of a personal and confidential character, was never placed in the files of the office, and I am unable to locate the same at this time. If, however, the matter is of any great moment I assume a copy might be obtained by correspondence with the cable company.

Very truly yours, T. P. Shonts.

Hon. J. H. Millard, Chairman Committee on Interoceanic Canals, United States Senate, Washington, D. C.

Compensation paid to Mr. Markel. (Report of Isthmian Canal Commission. Minutes of Panama Railroad Company.)

Resolved, That for special services and expert advice rendered and disbursements made by Mr. Jacob E. Markel, the

sum of $10,745.97 be, and the same is hereby voted to him, this payment being in full settlement.

Ships Worth $425,000 Cost $650,000 Each.—5.—Purchase of steamers Havana and Mexico for $650,000 each, whose value as given by insurance was $425,000 each. (Senate Investigation.)

Mr. Shonts: This man, whose name I cannot think of just now—this representative—it is unfortunate that I do not remember names better—the representative of the Cunard Line in New York. I said: "I am willing to pay, flat, $650,000 for each of those ships, subject to survey and inspection, if they are all right, but I will not pay a cent over."

Senate Investigation, Testimony of Secretary Taft.

"The purchase was made by Mr. Shonts, through Mr. Vernon H. Brown, of the Cunard Line."

Mr. Vernon H. Brown belonged to the old Panama Railroad group of directors. (Investigation of Panama Railroad.)

Insurance was $450,000 when vessels were purchased. This would represent the value as estimated by the insurance experts.

6.—Issue of $628,000 railway bonds at 4½% to lend money to Canal Commission, in default of Congressional appropriation. (Senate Investigation.)

Senator Morgan: The appropriation that was made for the building of the canal down there had been either so reduced or so expended as that the commission was unable to pay the $600,000 to the railroad company.

Mr. Shonts: That was it.

Senator Morgan: You sold the bonds in consequence of your inability to collect the debts from the canal commission?

Mr. Shonts: At that particular time; yes, sir.

Senator Taliaferro: Was the secretary of war consulted about the sale?

Mr. Shonts: No, he was not.

When he was made cognizant of it the bonds, which had been sold to Mackay & Co., were repurchased, the transaction having cost $3,000. (Senate Investigation, page 1,442.)

Senator Morgan: Suppose, Mr. Shonts, that it should unfortunately turn out that this $3,000 of interest had been received by these gentlemen who are on the board of directors and paid out to the company, and that they should be personally liable for it, because they did not have any right to do it—would that obligation involve also the minister from Panama? (Who is a director.)

Mr. Shonts: That is a legal matter that I will not undertake to pass on.

Since this investigation the railway has been constantly used as the indirect buyer, dealer in coal, mess supplies, etc., and as cold storage purveyor.

Exorbitant Panama Rates.—Letters of Chief Engineer Wallace in Report:

The data contained in the annual reports of the Panama railroad are unsatisfactory. From an analysis of these reports it is difficult to make an exact determination of what has been the actual cost of transportation of freight across the Isthmus. Judging, however, by such information as can be obtained from these reports, it would seem to approximate roughly $1.30 per ton, not including the expenses of the New York office or the fixed charges, interest or dividends, but including all the cash outlay on the Isthmus for the maintenance and operation of the property.

Report of Joseph L. Bristow, page 244:

This statement shows that the cost of handling freight per ton over the railroad lines, as applied to all the expenses on the Isthmus, amounts to $1.256 per ton, or approximately 2.6 cents per ton mile.

On page 246 a letter of Chief Engineer Wallace says:

I desire to remonstrate against the work under my charge being increased in cost due to paying the Panama Railroad Steamship line $5.00 per ton on freight from New York to Colon, when it only receives $3.57½ per ton on other freight from New York to Colon, destined to San Francisco.

And again in a letter to Admiral John G. Walker, dated Panama, March 23, 1905:

"The equity of the situation would seem to be that the United States government is certainly entitled to as low a rate for the transportation of its material and supplies as it is possible for the Panama Railroad Steamship line to make without loss. It is certainly entitled to as low rates as may be given to any other shipper using that line. These would seem to be at least fundamental propositions.

That large profits have been made by the Panama Railroad Steamship line during the last year, due to the business furnished by the United States government, is self-evident, and the comparative statement of the net earnings of the transportation company since the canal construction commenced, as compared with the previous year, bears out this statement. That these undue profits will rapidly increase from now on is also self-evident.

As is well known, a large part of the business of the Panama railroad consists in through business between San Francisco and New York. The data which have been furnished the chief engineer show that the through rate is $11.00 per ton, regardless of classification or character of goods. It also shows the Panama Railroad company receives only $1.92½ for the transportation of this freight across the Isthmus of Panama from ship's side to ship's side; and the Panama Railroad Steamship line $3.57½ for the transportation of

the business from New York to Colon; the combined rate from New York to Panama being $5.50 per ton on freight destined to San Francisco.

As against this the Isthmian Canal Commission is charged $5.00 per ton on freight from New York to Colon, and $2.00 from Colon to Panama, a total rate of $7.00 per ton, for the same service and the same distance, with the exception that the Panama railroad does not have to stand any proportion of the cost of unloading the freight consigned to the Isthmian Canal Commission, which cost, considering the nature of the freight handled and the larger number of tons which can be loaded per car, is at least equivalent to 25 cts. per ton; making a practical discrimination against the commission of the difference between $5.25 and $7.00 per ton, or $1.75.

While there may be competition between New York and Panama necessitating a lower rate on this business, there is no reason why the Isthmian Canal Commission should not be entitled to as low a rate.

Even if the New York and San Francisco business is carried at a loss, it is not clear why the Isthmian Canal Commission should be taxed to make good or compensate the Panama Railroad and Steamship line for the amount it loses on other business. That line should certainly not be subsidized to this extent from the appropriation of the Isthmian Canal Commission for the purpose of maintaining through transcontinental competition.

A collateral feature of the question of rates is the high rate which the Isthmian Canal Commission is required to pay on freight from New Orleans shipped by the United Fruit Company's steamers. The question immediately presents itself as to why the traffic officials of the Panama Railroad Steamship line should be called upon to negotiate for or in any way assist in the securing of rates by rival lines.

No matter how well disposed those officials may be toward the Isthmian Canal Commission, their entire education and trend of thought have naturally been toward using every possible effort and all means at their command to build up and increase the earnings of the Panama Steamship line.

By having the power to grant or deny to the United Fruit Company the right of through billing over the Panama railroad, as an inducement to make such rates between New Orleans and Colon as might be satisfactory to the Panama Railroad company, it would seem that the traffic officials of the latter company are able to dictate the rates which the United Fruit Company should charge on freight between New Orleans and Colon.

If comparison is made with the rates which the United States government pays for the transportation of freight between New York and the Philippines, and also with the rates which are charged in the United States for similar service, it will be evident that $3 per ton as an ocean rate from New York to Colon, and $1 from Colon to Panama, is

liberal compensation to the Panama Railroad Steamship company and the Panama Railroad company for the handling of the commission's business, and it is recommended that the matter be adjusted on this basis."

Senate Investigation, page 3022:

"The only direct steamship line from New York to Colon is that controlled by the Isthmian Canal Commission.

This line names the arbitrary rate of $5 a ton of 2,000 lbs. on cement, to apply to the requisition covering delivery of cement up to December, 1906. This is at the rate of $1 per bbl.

There are a number of lines of steamers running from England, Belgium, Germany, etc., touching at Colon, carrying general cargoes to South American ports, and on these steamers rates as low as 60 to 68 cts. per bbl. on Portland cement can be made, though the distance is about double that from New York to Panama. Further than this, tramp steamers going to South American ports from Europe for return cargoes have named rates for delivery of cement as low as 45 cts."

A reduction of rates is now alleged.

Claims of important reductions in rates via the Isthmian Route have been speciously made. As proof that rates have been little changed we transcribe the following table from the railroad reports:

Ton Rates.

Through.	1906.	1905.	1904.
From New York	$3.46	$3.71	$3.54
From New Orleans	3.49	4.17	4.62
From Europe	3.66	3.97	3.78
Total	$3.56	$3.84	$3.56

Rates for ton continued:

Local.	1906.	1905.	1904.
Commercial	$3.98	$4.12	$4.12
Isthmian Canal Commission	1.92	1.49	3.28

Local Isthmian fares are a grievance. By the February, 1905, reductions, the through New York passenger fares across the Isthmus are now $6.50 to $6 first class, with 200 pounds of baggage free, and $4.50 steerage. This is a first-class fare of 13.5 to 12.5 cents a passenger mile. The local passenger rate without baggage, which is heavily taxed, is $2.50, or 5.2 cts. per passenger mile. The railway manager stated before the Congressional Investigating Committee that the average fares were about $4.50 a ton and a passenger from Colon to Panama, 9 cts. a ton and passenger mile.

Local Rates Reduced.—In regard to this matter an official report states:

"Local rates were formerly excessive, but a new schedule adopted Febraury 1, 1905, appears to be reasonable, and has relieved, in a great measure, the cause of this complaint."

The rates on a few commodities in the different classes as given by the local schedule of February, 1905, are cited below that the reader may judge for himself. The towns of Colon and Emperador are used as an example:

Colon to Emperador.	Cents, Ton Miles.
Class 1. Furniture, 65 cts. a 100 lbs.	41.6
Class 2. Canned goods, 60 cts. a 100 lbs.	38.4
Class 3. Bananas, 45 cts. a 100 lbs.	28.8
Class 4. Machinery, knocked down, 30 cts a 100 lbs.	19.2
Class 5. Lumber (shipped to load and unload), 19 cts. a 100 lbs.	12.1

These rates are from 10 to 40 times those of the New York Central. This, then, is the present status. For local products the rate is reduced one-half. For American or other goods imported it stands unchanged!

In the United States the average ton mile rate is .785 cts. and 2.065 cts. a passenger. In India on the Government railways the average ton mile rate is .81 cts. and passenger .43 cts. It is, of course, quite true that no arrangement can be based on these figures, but they have their significance. If a transportation charge, however, be made of 75 cts. a ton and a passenger, and if 25 cts. be fixed as a reasonable handling charge, using up-to-date machinery (it is about 13 cts. at Galveston), the total becomes $1, or a sum commensurate with the $1 a net registered ton to be charged a vessel through the canal. This is 67 cts. a ton weight. Counting in the difficulties of tropic conditions, the cost of oil, fuel, etc., it is apparent that the actual cost a ton and a passenger for transfer across the Isthmus makes $1.50 an ample allowance.

Mr. Richardson: The government owns all the shares of that road.

Secretary Taft: Yes; but it does not own all the road, strictly speaking, because there is a mortgage for several million dollars, I think, securing bonds issued and in the hands of private persons.

Mr. Bartlett: Who pays the interest?

Secretary Taft: The government pays the interest on these bonds.

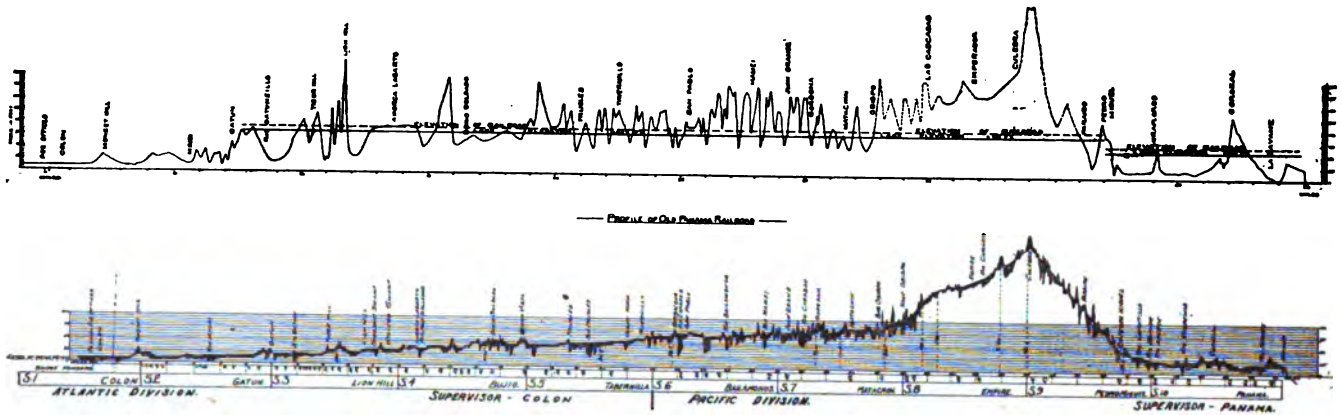
Mr. Mann—The railroad pays the interest.

Secretary Taft—Yes, the railroad pays the interest.

Mr. Burke: What rate of interest does it pay?

Secretary Taft—I think it is 4½%.

The Chairman: The practical result is that the govern-



PROFILE OF OLD PANAMA RAILROAD.

ment of the United States is paying itself 4% interest for the use of its own money.

Mr. Shonts: The railroad pays the interest.

The Chairman: The government owns the railroad?

Mr. Shonts: Yes, sir.

The Chairman: The practical result is that the government is paying itself 4% for the use of its own money?

Mr. Shonts: Yes, sir.

An act necessitates an actor. The policies of a corporation are not intangible mechanical doings of an abstraction, they are thought out directly by minds. For a complete understanding of the situation it is necessary, therefore, to study the men and their opinions.

Attitude of the Secretary of War.—Statement before the Senate Committee by the Hon. William H. Taft:

"I hope that nothing will be done to merge the corporate entity of the railroad company into that of the government or the commission. Under the present management it is just as easy to have close supervision over the management of the railroad as if it were nominally operated by the commission, and the corporate form secures the utmost convenience and elacticity of control."

The Senate this winter passed a bill, 6523, for the Government to do away with the corporation form of the Panama Railroad. It failed of passage in the House.

From hearings before House Committee last session:

Mr. Richardson: I understood your objection to having the government take charge of the railroad was really based upon the idea that the government ought not to enter into government ownership of anything.

Secretary Taft: Oh, no, sir. It is a matter of convenience; that it all.

Mr. Ryan: Now, pursuing my question——

Secretary Taft: If I may add a word before answering your question. I would say that one of the advantages in maintaining the railroad is in the opportunity it gives for observing whether the railroad is being run economically or not. Treating it as a private corporation and treating it as a separate entity affords the opportunity for judging at once whether or not the railroad is run as it ought to be.

Mr. Mann: Mr. Secretary, in connection with this question of the Panama railroad, would you care to submit a statement in writing covering your objections to that bill?

Secretary Taft: The great convenience of an artificial entity like that, which has the obligations and powers of a private corporation, in carrying out the work of a railroad, I can hardly exaggerate.

Mr. Wagner: Then you do not recommend the passage of the bill?

Secretary Taft: No, sir; I do not.

Secretary of War's Confidence in William N. Cromwell.—"His intense interest in the success of the Panama canal has been evident at every point, and he has rendered most loyal, efficient and valuable service for the comparatively meagre compensation which he receives as general counsel for the railroad company."

William Nelson Cromwell wishes to preserve existing status. Page 62. Investigation of Panama Railroad.

"I esteem it of high consequence to the United States that the legal entity of the Panama Railroad company be maintained, and that the concession be preserved in its original integrity."

William N. Cromwell's Diversity of Interests.—a.—Attorney for Panama railroad and director during canal liquidation. Was cognizant of all transactions and contracts entered into from 1880 to the present. (Investigation of Panama Railroad, page 126, 129, Senate Comm., page 306. Bristow Report, page 101.)

b.—Attorney for French company since 1896 in Colombia negotiations and in transfer of $40,000,000 paid for canal. (Senate Investigation, page 1085.)

c.—Special Fiscal Commissioner of Republic of Panama in the investment of the $10,000,000 received by them. He invested $1,000,000 in Panama railroad bonds. (Investigation of Panama Railroad, page 129.)

d.—Stockholder in American Trade Development company, selling ice and electric power in competition with government plants. (Senate Document No. 127, Part 2, page 35.)

e.—Pushing claim for an extra compensation of $2,000,000 to the French company beyond the $40,000,000 paid. (Senate Investigation, page 2555.)

f.—Cognizant of 8% dividend paid to French stockholders of record after the United States government had accepted the property. (General Davis Report, page 5.)

g.—Representative of Panama Republic signing agreement with Canal Commission by which a percentage of government payments is made to Panama banks for their services. (Isthmian Canal Commission Report, page 202.)

h.—Adviser of $233,000 "emergency contracts" let by commission without competitive bidding under cover of railroad. (Investigation of Panama Railroad, page 358.)

i.—Took part in arranging the Markel contract and the handing over to Markel of $10,000 after its abrogation. (Senate Investigation, page 347.)

j.—Proposed resolution authorizing second railway bond issue, by which the railway increased the government debt, to lend money to commission. (Report of Isthmian Canal Commission, page 350.)

k.—Received $72,000 from government in payment for 270 railway shares reported secured from private stockholders and turned in by him. (Isthmian Canal Commission, page 340.)

1.—Is accustomed to prepare the official minutes of the railway company, in accordance with his own views of what has happened and the best way to express it. (Senate Investigation, page 362.)

Senate Investigation, page 356.

Senator Simmons: But the law did require the commission to award these contracts to the lowest bidder, did it not?

Mr. Shonts: That was not a commission contract.

Senator Simmons: But do you think that you could avoid that express provision of the law by shifting this contract from the commission to the railroad?

New York Tribune, April 16, 1905, Washington dispatch:

Chairman Theodore P. Shonts of the commission was authority to-day for the statement that the long-predicted shake-up in Isthmian freight and passenger rates will not take place. Mr. Shonts said:

"Nothing will be done that will disturb the balance of transcontinental rates. The Panama Canal Commission will not do anything that will affect the stocks of lines owned by American citizens. If at any time in the future the railroads engaged in the transcontinental traffic should menace the welfare of the country by entering a monopoly that proved to be a national hardship, the Panama railroad might be used by the government as a factor to bring them to terms. The government owns the road and will use it for the best interests of the citizens. As for the monopoly that the Pacific Mail Steamship Company is said to hold by reason of its contract with the railroad company, I do not think that it is a matter of great concern. The concessions it enjoys, if any, from the railroad are not of such size as to play a part in transcontinental rates."

He received a salary of $12,000 a year from the Clover Leaf Railroad, of which he is president, all the time he was Chairman of Canal Commission. These are the advocates of the perpetuation of the railroad corporation entity. Why not incorporate the Supreme Court and the Post Offices?

For the purposes of the Panama Railway Company for the year 1907 a large sum, over a million, was authorized. As illustrating the precise and business-like methods employed throughout our enterprise under the direction of the Secretary, of War, we quote from recent hearings before the Appropriations Committee of the House. Everything went.

The Chairman: Mr. Shonts, was the estimate of $2,256,180 for the department of construction and engineering made up by Mr. Stevens or by yourself?

Mr. Shonts: Mr. Stevens made up an estimate based on a letter which he interpreted wrongly. We suggested that, for the purpose of comparison, he use a certain month, and in place of using it for the purpose of comparison, he used it as a basis for his estimate, and when he sent his letter with inclosure he said: "This, you know, is the rankest guess, as all of these estimates are, for that matter," and on that basis he made his estimate less than a year before, whereas it should have been larger, because they will work more men, and we added $250,000 arbitrarily to the figures in his letter in order to arrive at these figures, to provide for necessary increases in the force.

I will say that in connection we added $2,000,000 to his estimate for skilled and unskilled labor under construction and engineering, for the reason that it was just a guess, and made up from a wrong interpretation of what we meant. We simply meant a comparison and he took it for a basis. I explained it all to him afterward."

Canal Construction Period.—Beyond this vital question of organization and management the railroad is of far-reaching and fundamental importance in its relation to the construction of the canal and to the commerce of the world during the construction period.

It needs no intimate analysis to decide at the outset that the Panama Railroad should be made and operated to serve the fullest needs of transit, commerce and canal construction.

The permanent line of the Isthmian Railroad must be fitted to the canal, not the canal to the railway, riveted to a location which would contribute to committing the United States to an inferior plan of water-way. New railroad work should be done after and with specific reference to the plan of canal adopted, because the detailed location and duty required for execution varies for every project, although in all instances the ultimate main line should be on the east side of the canal. In a year, by erecting low dykes and barrages across the Chagres and the Rio Grande rivers, two lakes can be made at the Atlantic and Pacific termini of the canal, navigable from Mindi to San Pablo and from Sosa to Pedro Miguel. These two lakes will reduce the land width of the Isthmus to 16 miles. If a third lake be made by a net head dam at Gatun, which can be accomplished in the same time, there will be only 8 miles of the land width left on the Isthmus. If Lake Chagres be set at 32.5 ft. and Lake Gatun during the construction period at 45 to 50 ft.—the present alignment of the railway can nearly all be used by raising the grade and bridges to correspond.

Much of the Work Must Be Abandoned.—Despite the double tracking of the road, widening grades, constructing culverts, bridging the Chagres, much of the work must be altered and abandoned to accommodate the canal. When the waterway is opened, a single line of rails from Mindi to Gatun and Obispo to Panama and fast steamers in the lake or a car ferry from Gatun to Obispo will be ample. At the ends of the new lakes may be erected temporary docks and terminals, which will be available in any event for canal construction.

Several millions have been expended in or appropriated for double tracking the Panama Railway almost its full length, during the past thirty months. The demand for this arose from the flood of material and supplies bought and the consequent congestion of commission and through freight. The expensive program was as ill advised as it was unnecessary.

The Panama Railroad was in 1906 double tracked out of Colon as far as Monkey Hill, and the Colon and Cristobal yards have been greatly extended. The yards at Colon, Cristobal and Monkey Hill would amount to three additional tracks from Colon to Mount Hope. Wherever new tracks have been put down, heavier rails have been used. The old rails were much too light for the new locomotives.

From Monkey Hill to Frijoles the railroad was still single track. From there on, with but two or three short breaks, the road was double tracked and ballasted to within one mile of Panama.

Most of this work must be abandoned and a new road built, due either to the location of the present line on the lowlands within the lake area or to its being on the wrong side of the canal.

Flimsy Piers at Cristobal.—At Las Cacadas, Emperador, Pedro Miguel and La Boca extensive yards have been constructed, and at the harbor terminals of the road, Cristobal and La Boca, several large piers. The La Boca piers are of better construction than those at Cristobal. The movement of ships against the piers at Cristobal have already bent them out of line. The construction is of the flimsiest kind. The piers will hardly last out the canal construction. There are two of these at Cristobal, one angle dock 540x700x25 ft. (four piles to the bent), and another 80ox100 ft. covered dock. The piers at La Boca are a direct extension of the old French piers, and, due to the recent changes in alignment,

this new work will all be lost on the completion of the canal. This also applies to the dredging being done in the Panama channel. About 850 lineal feet of new dock have been built and the old French dock widened out.

There seems to be no reason why these terminal works might not have been of a permanent character, properly located with respect to the finished canal, had the plan of work been less nebulous.

Miles of the rails that have been laid and grading that has been done might just as well occupy the final position which the road must take.

During 1907 vast sums have been expended in new grade and track changes. One-fifth of the employees at the Isthmus are engaged upon the railroad in September.

We quote page 94 of the Advisory Board report, in relation to the necessary change of railroad and the reconstruction of its mileage for service after the canal is finished:

"Between Mindi and Gatun recent surveys show that the work will not be particularly heavy or expensive. Between Gatun and Bohio no recent or complete surveys are available, but the information at hand is sufficient to show that a reasonably direct line crossing the lake and taking advantage of the support afforded by the highlands along the route is preferable to one going around the lake. There will be some heavy work along this line at the crossing of the Gatun and other valleys, the maximum height of embankment being about 80 ft., which is not unusual in railroad construction.

From Pedro Miguel toward Panama the railroad may be located without special difficulty around the margin of Sosa lake until the northerly end of the Ancon-Corozal dam is reached, and it can then run along this dam, which furnishes a direct route to Panama.

For the ten miles of relocation required between Mindi and Bohio, $2,000,000 have been included in the estimate, and for the six miles between Pedro Miguel and Panama, $400,000 have been included. The estimate of the Isthmian Canal Commission of 1899-1901 for 24.5 miles from Bohio to Pedro Miguel is, in round numbers, $1,300,000, making the total estimated cost of the relocation of the railroad $3,700,000."

A commentator writes: "It is thought that not a dollar of this can be saved, although when the canal is finished, the railroad will become almost useless." Indeed it should nearly all be saved.

This is a serious report and a serious proposal. Let us examine this "80-ft. embankment."

The Maltby survey is only from Colon to the Gatun ridge, a distance of 16,000 ft.—3 miles. If the grade across

Gatun Lake is put high enough to guard against the risks of subsidence and compression of the swamp muck, it is safe to say that the embankment from the Gatun ridge on Tiger Hill will measure from top to bottom (including 10% only for sinking of the swamp material) not 80 ft., but at least 90 ft. in height. Doubtless it will be allowed a top width of 24 ft. Since it is across a lake the side slopes will be flat and on account of waves it must be thoroughly rip-rapped on both sides, or be built of rock spoil, like the exposed front of the Gatun dam. Then we have a section which runs about 1,000 cu. yds. a lineal foot.

Great Cuts and Fills and Bridges.—From the only surveys extant it appears that this embankment may total from 7,000 to 10,000 ft. long, and must contain 7,000,000 to 10,000,000 cu. yds. Besides this there are other great cuts and fills and bridges. One cannot help knowing that the $2,000,000 estimated for the "10 miles" to Bohio will be largely exceeded. No wonder the ex-chief engineer, a practical railway man, says he does not think it will pay to build such a line.

To emphasize the utter fatuousness of the expert estimate of this 35 miles of construction, there has been prepared from the best existing contour maps of the Isthmus a profile of the new railway around the shores of the to be created Lake Gatun and above its 85-ft. plane.

The ravines and arroyas are so numerous, the hill spurs are so high and steep that even with all possible savings of excessive curvature the grades become a succession of deep cuts or tunnels, huge embankments, culverts, bridges and viaducts.

The embankments across the arms of Gatun Lake are formidable, indeed, to contemplate. The clay of the Isthmus when saturated will not stand in the lake at temperate zone slopes; it must flatten out to 5 or 6 to 1, and prove there most difficult to maintain.

Wicked Waste of Millions.—When one considers the car ferries of Lake Michigan, it seems both absurd and wicked to contemplate a waste of millions on such a profile as is here indicated. A steamer line or such a car ferry can ply readily between Gatun and Obispo, and be cheaper and safer for all that will be wanted here of the railroad after the canal is in operation. A car ferry could certainly be regarded as an integral part of the railway service which by

treaty is to be continued after the canal is done, or the treaty can be modified.

During the construction period comparatively little grade raising is required to lift the present tracks above the low level lakes advised during the time of execution beyond Mindi and Gatun and between Sosa and Pedro Miguel.

Since the Government has made its internal canals and water highways free of tolls, so it might wisely in fosterance of our merchant marine make the Panama Railway free to coasting trade between our Atlantic and Pacific seaboards and to export and import trade into Atlantic and Pacific ports carried in American vessels. Such a policy would vastly benefit the whole people and especially the American marine, which so sorely needs it. It would be identical in principle with the assumption of Suez Canal dues by several European Governments. Suez dues work out $1 a ton weight, and this rate, with proper plant and equipment, would practically cover the actual cost of transferring cargoes across the Isthmus.

The principle applied at Panama would assure active competition and the carriage of canal supplies at low rates in American vessels.

SUMMARY.

This series of papers has now reviewed the Panama Canal in its three aspects—financial, executive and technical. The facts have been set forth and the necessary conclusions deduced from them. A general summary of what the evidence proved is in order.

The foreword recalled that we are no longer a small band of colonies separated from the Old World by dividing oceans. We have become nation of nations, with wide seas, binding, not sundering. We are possessed in these latter days of an Oriental domain which we must defend. The southern half of our westland continent is stirring in the great living impulse of growth. We must weave and knit our national ideas and influences as we lead the mighty march to the goal. Again we have become Mother Earth's greatest producers, and our prosperity demands not a limited but a universal market.

Because the Panama Canal is indissolubly part of America's power, of her chance, of her race-right, of her duty, it must be built at whatever cost and sacrifice.

The waterway is one of the specialized undertakings whose success or failure depends primarily upon the right technical judgment. Good managers or bad managers may be important, but they do not carry the very existence of the enterprise in their decisions. Engineering, however, lies at the sources of its being; it is the very well spring of the canal's life. So essential is right engineering to its vital possibility that no man can be considered a friend who intrusts its destinies to the wrong order of technical mind. Its whole execution and its entire future of service sway upon these verdicts, and the loyalty of each and every official must be measured directly in his fearless elimination of the wrong men from its affairs.

The technical decisions unto which the Panama Canal has been committed have been shown for what they are. When these are measured and are understood, then and then only shall deliverance be worked out for the waterway.

For purposes of comparison the characteristics of the lock-flight project with the summit level set at 85 ft. above mean sea-level, are contrasted with those of the Three-Lake plan with its summit lake at 62.5 ft.

1.—LIMON BAY SECTION.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—Approach Entrance. The Atlantic end of the approach is too close to submerged Manzanillo Reef off Colon.	1.—Approach Entrance. Seaward end of approach is set one mile to westward of reef, affording ample sea-room.
2.—Terminal City. Colon, a foreign city, the terminal for shipping. Over a swamp, filthy and a focus of disease.	2.—Terminal City. Colon abandoned except for use during construction. Terminal city on Mindi Hills. American, high, clean and sanitary from start.
3.—Seven miles from first lock.	3.—Adjacent to first lock.
1.—Breakwaters. Breakwaters of experts and commission, totaling 5⅛ miles in length, extend seaward in northerly direction and converge at entrance.	1.—Breakwaters. Eight hundred foot entrance between east and west arms, which extend from Mindi Point westward 6,000 ft.
2.—No explorations or borings under east arm one mile, none under west arm 3½ miles.	2.—Explorations and borings show formation and depth to rock.
3.—Mud and hard bottom depths unknown.	3.—Mud and hard bottom depth known.
4.—No guess possible as to volume or depth of breakwaters.	4.—Volume and depth of breakwaters known.
5.—Estimates fictitious and conjectural.	5.—Estimates closely approximated.
6.—Twenty-ton concrete or stone blocks for breakwaters imperative on account of high wave exposure.	6.—Normal construction and rock of proper size available along canal and lakes made.
7.—Such unavailable. Argosies of ships needed to carry materials, and stupendous cost.	

8.—Alignment of breakwaters oblique to rollers, bad in "northers."
9.—Cost much over the $5,300,000 estimated.
10.—Remaining four engineers turn down their own and minority breakwaters and next show none at all. Breakwaters indispensable, hence Atlantic harbor arrangements cannot be a finality. Radically wrong.

8.—Location correct to best withstand waves.
9.—Cost less than one-fifth Board system.

No Breakwaters.

1.—Channel in Limon Bay being wholly unprotected by breakwaters, it results:
(a) That it is impracticable to dredge inner mile from Mindi Point to Mindi on account of lee shore, shoal and constant rough water from trade winds.
(b) Material too light to deposit in hopper dredges and sea always too rough in inner mile at head of bay for smooth water dredges.
2.—On inner mile, if channel existed, it would have nothing to defend it from rapid resilting by "northers," heavy gales and from constant agitation of mud bottom by waves of on-shore trade winds.
3.—No outer salt water harbor. No haven or refuge anywhere near entrance to canal.
4.—No reclamation on shore.

5.—Channel for inner mile of approach subject to sudden resilting from storms.
6.—High wave motion in narrow lee-shore channel from Mindi Point to Mindi destroys safe steering, and passing of steamers is hazardous.
7.—High waves on starboard quarters of steamers create, in this mile stretch, liability for ships to sheer and go ashore.
8.—No outer harbor suitable for naval base.
9.—No outside anchorage for merchant or naval ships.
10.—Silt jelly from Limon Bay provided as a sliding cushion for heart of Gatun dam.

Proper Breakwaters.

1.—Channel from Mindi Point to Mindi protected by east and west breakwaters, from which it results:
(a) That it is practicable to dredge upper end of Limon Bay by smooth water dredges in all weathers.

(b) Material can be directly dredged and put ashore.

2.—Channel silting is minimized and the navigable channel and harbor area are easily and cheaply excavated and maintained.

3.—Fine outer salt water harbor and haven of refuge.

4.—Valuable reclamation at Mindi terminal.
5.—No menace of sudden resilting, which must be a very slow process on account of breakwaters' position.
6.—No wave motion except where there is plenty of sea-room, outside breakwaters.

7.—No waves at all in inner mile.

8.—Outer harbor for naval base.

9.—Safe anchorage for larger fleets.
10.—Silt spread over marshes making valuable land.

Conclusion.

"Northers" are of such hurricane violence that all admiralties notify ships to keep steam up in readiness to put to sea. The coming of storms cannot be predicted. Breakwaters from Mindi Point westward are absolutely indispensable.

The Lake canal's Atlantic approach, breakwaters and outer harbor are technically correct, and are readily created and maintained.

Government project vitally defective and inadequate for commerce.

II.—MINDI-GATUN SECTION.

85-Ft. Lock-Flight Project.

1.—No suitable inner harbor affording protected naval station and haven for shipping.

62.5 Ft. Three-Lake Plan.

1.—Inner harbor bordering new terminal city on Mindi and Jaramillo Hills; perfectly protected from

2.—Navigation and mooring in a constricted channel.

3.—Eleven million cu. yds. of dredging, of which at least one-third, 3,667,000 cu. yds. is clay rock, costing millions to excavate.

4.—Swamp of quicksands needlessly and unfortunately preserved, and hence not sanitized, and impossible to redeem other than by drowning morasses.

5.—Superficial 6-minute examination of Mindi site by "experts" in driving rain.

6.—Favorable reports ignored.

7.—Most favorable sites for lock and dams on whole canal, those at Mindi and on lower Chagres unutilized.

"northers" and large enough for all navies. Naval station pre-eminently safe, protected by encircling hills and adjacent to outer salt water harbor.

2.—Open navigation on Lake Chagres from Mindi lock No. 1 to Gatun lock No. 2.

3.—On account of lake, very little dredging. What exists is in upper soft strata. No rock excavation.

4.—Swamps submerged, hence section sanitized. Submergence to be effected as a first step in programme of execution of canal.

5.—Rock foundations for Mindi barrage and locks.

6.—Rock foundations nearest to surface of any on Isthmus.

7.—The pervious and artesian strata of Gatun geologic gorges cut off at Mindi.

III.—BATES REEF ACROSS LOWER CHAGRES.

85-Ft. Lock-Flight Project.

1.—Simple meager reconnaisance without instruments, no knowledge of reef, none sought. No maps, no profiles, no data of any value obtained in three years as to Chagres river below Gatun, nor as to crest-line west of Jaramillo Hill, when, in fact, at least three dam sites exist of a favorable character below Gatun.

2.—The proposers and defenders of the lock-flight project are indifferent to this reef, the most important fact in the whole geology of the Isthmus. Ignoring its supreme advantages they commit the country to the deplorable Gatun dam and lock-flight, and violate every axiom of conservative and safe engineering and of navigation.

3.—High Lake Gatun cannot be created until huge dam and spillway are completed—in ten years or more.

62.5-Ft. Three-Lake Plan.

1.—At Bates Laja Reef the writer has made known the results of accurate surveys demonstrating the existence of a rock-reef completely across the Chagres joining the extension of Jaramillo Hill and the hills on the west side of the Chagres. This affords the only known place on river below Gamboa where a dam to bedrock is feasible.

2.—Pervious and artesian strata are cut off at Bates Reef across lower Chagres. Foundations at reef for solid barrage on rock only 3,000 ft. long.

3.—Dispositions of low barrage and first lock at Mindi and second barrage at the Bates Laja Reef secures a number of vital and valuable betterments:

(a) Do away with lock flights and substitute single separate locks.

(b) Do away with high dams and substitute low dams.

(c) Do away with high lakes and substitute lakes, low, yet ample for navigation and of equal value for transit.

(d) Enable floating plant to be employed from Mindi to Obispo and to attack the central mass.

(e) Enable a small net head dam to be placed at Gatun.

(f) Dangers of undermining are eliminated by rock founda-

tions to dams at Mindi and at the Bates Chagres Reef.

(g) By their adoption and construction as a first step the width of the Isthmus can be narrowed in a year to 16 miles, and in 2 to 8 miles. This narrowing will as a sanitary measure save many millions and many lives; as a construction measure it solves the labor problem, and it greatly facilitates and expedites execution.

Gatun Lake can be created at end of second year.

CONCLUSION.

Setting first barrage and lock at Mindi, and barrage at Reef, interposing terminal Lake Chagres, insures to this section a canal with single separate locks, safe, low dams; the longest water area for navigation, the best sanitation, the easiest and cheapest construction.

IV.—GATUN DAM AND FOUNDATIONS.

85-FT. LOCK-FLIGHT PROJECT.	62.5-FT. THREE-LAKE PLAN.
GATUN DAM.	GATUN DAM.
1.—Unnecessary high lake at 85 ft. fills hill bowl to the brim and necessitates raising of rim in several places up Trinidad Valley. Requires locks in flight and six locks.	1.—Level reduced to 62.5 ft. does not menace brim, yet owing to steepness of hills, the lake is equally serviceable for: (a) Regulation of Chagres. (b) For navigation. (c) For lockage supply. (d) No locks in flight and but four sets of locks in whole canal —The two sets of locks saved are an offset to extra excavation in Culebra.
2.—Unnecessary high dam with 85 ft. head containing 21,200,000 cu. yds.	2.—Lower dam of one-fifth the volume.
3.—Alluvial foundations.	
4.—Geologic gorges filled with pervious and artesian strata.	
5.—Permeable strata subject to erosion found from 81 ft. to a depth of 204 to 268 ft.	5.—Pervious and artesian strata blanketed by lower lake at 33.5 ft. and cut off by Lower Chagres barrage upon the reef below Gatun.
6.—Water under hydrostatic pressure rises from 8 to 17 ft. above river.	
7.—Impounding lake increases artesian stresses.	
8.—Underground Chagres enormous in volume.	
9.—Subterranean conduits focus down Chagres.	
10.—Pervious strata impossible to curtain off to the rock.	10.—With certainty of cutting off underground flow at reef and Mindi and blanketing by Lake Chagres, foundations are safe for a Gatun dam of one-fifth the volume and low head.
11.—Experts and Commission directed that this be done preliminary to building dam.	
12.—Net head on dam, 85 ft.	12.—Net head only 29 ft.
13.—Pressure on lake or reservoir bottom up to 40 lbs. per sq. in., creating serious hazards as to undue percolation and erosion through per-	13. Pressure on lake or reservoir bottom only about one-third of the other. No danger of undue percolation or erosion.

meable strata under dam and at locksite.

14.—Gatun Lake covers all avenues to geologic gorges under dam.

V.—CONSTRUCTION OF GATUN DAM.

85-Ft. Lock-Flight Project.	62.5 Ft. Three-Lake Plan.
1.—Hydraulic method for construction impracticable.	1.—Construction brought within mechanical limits of this process.
2.—Task set is lifting to 50 and 80 ft. heights after pumping thousands. Highest yet attained is lift of 35, after pumping distance of 2,000 ft. Hydraulic machines selected by Minority for cutting clay-rock now declared frivolous proposition.	2.—Dredging of clay-rock all eliminated.
3.—Difficulty of access for anything but cars.	3.—Dam-site accessible to dredges and tugs, barges and cars.
4.—No estimate for opening lateral approach canals.	4.—Dredges and barges can be extensively used, thus relieving Panama Railway and reducing cost.
5.—If excavated by other dredges and brought by barges construction method still experimental. (a) Silt jelly provided for dam from approach cannot be barged—it is too light. (b) Clay brought will be largely in chunks, requiring granulation. (c) Pumping this melange by relays never achieved.	5.—No silt jelly to be used. All put ashore to make valuable terminal reclamations near Mindi.
6.—Prescribed process counted in no such incidents.	6.—All difficulties are resolved by low net head dams, lower lake and rock foundations.
7.—Estimates were based upon hydraulic cutting and lifting.	
8.—Excess cost inevitable. If material be brought down from Culebra and lifted into the dam;	8.—Amount required but one-fourth or less.
9.—Cost much beyond hydraulic method prescribed.	9.—Material is right at hand in locksite and on shores of 33.5-ft. lake, whence it can be brought by scows, which can navigate freely from Obispo to Mindi.
10.—Time much greater—600 12-cu. yd. carloads required every day for 10 years to bring material to dam. Tremendous rail equipment demanded.	10.—Floating equipment extensively used. Minimum possible time.
11.—Enormous amount of labor.	11.—Minimum amount of labor.

VI.—DANGERS TO GATUN DAM.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—Subsidence owing to its weight upon soft upper clays and saturated permeable under strata. Settlements and fissures, particularly at the four points of crossings from surface soils to sandy gorge formations.	1.—Has but one-quarter the volume and far less weight, hence dangers from subsidence, fissure, settlement, breach, percolation eliminated. Dangers also eliminated by low head and lower lake and the fact that Chagres and Mindi barrages are on rock and so curtain underflow.
2.—Overtopping during construction because volume so great and time of construction is so long. Crises during floods owing to inadequacy of spillway.	2.—No danger from overtopping because of smaller volume and great facility of repair and because all flood currents are stopped many miles away by the 33.5-ft. lake

created by the lower dams first built at the Bates Reef and Mindi.

3.—Percolation under the dam and erosion of sand veins from high pressure.

3.—Low pressure, no danger.

4.—Earthquakes—The canal is in the earthquake zone.

4.—Relatively small loss possible from earthquake.

5.—Particular difficulties of repair:

(a) Culebra material will have been removed.

(b) Construction track system and equipment will have been removed.

(c) Height makes dredging from swamp bottom by hydraulic machines impossible.

(d) Car-fill system must be reestablished at large cost and delay.

(e) Available material hard to supply again from Culebra and very expensive and time consuming.

5.—Repair easy by dredges and material available.

6.—Chagres bed 58½ ft. deep, below and parallel to foot of dam probably exposes permeable strata. Impounded high-lake increases under-flow.

7.—Vertical pressure of lake brought right at hand much greater than flow down hydraulic incline gradient.

8.—Frictional resistance diminished, underground hydrostatic pressure increased.

6, 7, 8.—Pool covered by lake. Upper lake increase of subterranean flow mostly neutralized by lower lake, and no undue stress brought upon strata under dam.

CONCLUSION.

That the massive high dam upon such foundations and under an 85-ft. head should be abandoned, and the dam of one-quarter the volume and about one-third the head should be incorporated instead.

VII.—THE GATUN SPILLWAY.

85-FT. LOCK-FLIGHT PROJECT.

1.—Spillway capacity 140,000 cu. ft. per sec., which is discharge past Bohio. Discharge past Gatun is nearly 250,000 cu. ft. per sec., hence, spillway is inadequate to cope with known floods of 1879 and 1906, and there should be provision for worse floods.

2.—Lake fills Trinidad valley to brim and ridge saddles require extra works and safeguards.

3.—Toboggan converging spillway design of Experts very dangerous. Water under 16 ft. head over crest 70 ft. falls in converging slide into shallow trough through marshes. Fall is 70 ft. in 287½ ft. Spillway channel debouches to Pool. Volume and velocity sufficient to begin eroding and back-cutting, menacing dam.

82.5-FT. THREE-LAKE PLAN.

1.—Sluiceway capacity 250,000 cu. ft. per sec. Provision is made at Pedro Miguel and Sosa to send large volume to Pacific Ocean, thus giving ample factor of safety against floods greater than any recorded.

2.—Lower lake safely below saddles of the Trinidad Hills and no structures required remote from the canal route.

3.—Under sluices empty into lower lake instead of river, and no danger whatever attendant. Discharge quite away from main dam and diverging instead of converging.

CONCLUSION.

That the constricted spillway imperiling dam construction leading to pool and inviting erosion be abandoned and the ample sluices discharging into lake below the dam be installed.

VIII.—THE LOCKS AT GATUN.

LOCKS IN FLIGHT AT GATUN—85 FT. LOCK-FLIGHT PROJECT.

FOUNDATIONS.

1.—Originally located on "four borings or rather three" for data by experts!

2.—Axis adopted cannot be changed on account of ravine.

3.—Upper lock to-day has inadequate data.

4.—Underneath all the tier, the clay-rock, which is really caked volcanic mud, overlies a mixed formation of "sand and gravel and clay."

5.—Soft rock blanket varies from 18 to 66 feet in thickness.

6.—Upper right guide wall overhangs rock and is founded partly on sand and gravel and clay.

7.—Under uppermost lock-works rock blanket must be cut away, hence, upper gate chamber and guide walls will rest on pervious stratum.

8.—Rock blanket nearly pierced at lock gate chamber between upper and middle lock.

9.—Rock blanket quite cut through, under gate chambers between middle and lower set of locks. Center and side walls rest on "clay and sand."

10.—Bottom of lowest gate must be upbuilt from mud-rock. Rock at lower lock 50 to 60 ft. below sea level, 60 to 70 ft. below morass.

11.—North end of lock for from 300 to 350 ft. must be upbuilt.

12.—All lower lock and part of middle lock are in the swamps.

13.—Both approach walls to lowest set of locks on north are for full length in swamp.

14.—No data for rock location under north approach wall, but dip apparently very deep.

15.—Indurated clay is caked volcanic mud-tufa.

1.—INTERPOSITION OF LAKE CHANGES CONDITIONS.

2.—Hydrostatic pressure due to high lake may halve factor of safety in lock walls.

3.—Overturning forces become greater because angle of repose is changed by saturation.

4.—Clays especially unreliable; moderately moist they stand at 50 degrees; saturated, they subside at 10 degrees.

5.—Clayey earths are most susceptible to deterioration, and admixture of sand accentuates this.

SEPARATE LOCK—62.5-FT. THREE-LAKE PLAN.

FOUNDATIONS.

One single, separate lock alone is installed at Gatun.

One long lock can be all founded in the tufa stratum.

No upbuilding.

Approaches are all on firm foundations and are built not of cribs on piles, but of concrete.

Room in hill for right safety device—bear-trap dam plan.

1.—INTERPOSITION OF LAKE CHANGES CONDITIONS. Since no masonry rests upon pervious layers these changes are not endangering.

3.—Since sides are imbedded, saturation does not menace.

6.—Boils and springs likely to develop during construction and after lake is filled.
7.—North approach walls on piles must be pressed by saturated morass.
8.—South aproach walls on piles in 85-ft. lake are flimsy and inadequate.
9.—No foundation for safe bear-trap dam to keep lake from emptying in case of lock accidents, because lock-site hill is too short.
10.—No foundations for extension of lock chamber to reach site of proper safety dam for same reason.
11.—To get in lock flight, swamp must be invaded, mud-rock sheet followed, deeply dipping under morass and substantial approaches at both ends of flight sacrificed.

6.—No boils or springs during construction, since the bottom is in tufa layer above water plane.
7.—North approach is of masonry, concrete, not piles.
8.—South approach not in lake bottom, but in hill formation.
9.—Good foundations for extension of chamber and for safety dam, because hill adequate when only one twin lock installed.

10, 11.—Plenty of room for everything in hill.

IX.—ELEMENTS OF SPECIAL PERIL IN FLIGHTS.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—Lock flight particularly difficult to negotiate, especially for battleships.	1.—No tiers, hence accidents minimized.
2.—Inadequate lock width must soon make dimensions hazardous for large craft.	
3.—Fall from upper lock to second lock, 28 1-3 ft. (1 ft. in 40), or 2½ times the fall of Whirlpool Rapids at Niagara (1 ft. in 100).	3.—Fall from upper lake is into large lower lake. There is no empty second lock, as locks are widely separated.
4.—Fall from upper lock to empty second lock, 58 2-3 ft. (1 ft. in 20), over five times rate of fall in Whirlpool Rapids.	
5.—Depth at Gatun greater than in Rapids.	
6.—Velocities and tumult in accident greatest at and near entrance to upper lock, where appliances are designed to be set. No safety appliances should be set in or near upper lock, but well away from it.	6.—Safety appliances 1,250 ft. away from lock.
7.—No canal has escaped accidents.	
8.—Majority figured frequency for Panama, upon especially favorable Soo record, and single, separate locks, at two a year. With tiers casualties are much increased, as they point out.	
9.—The Soo basis shown by them to be inapplicable because of Panama conditions. Ore carriers who mostly use the Soo are familiar with the route. Closed for five months a year, when it can be overhauled and repaired.	
10.—Panama frequency rate inferentially much less favorable.	
11.—Six locks multiply risks.	11.—Four locks in place of six diminish risks by one-third.
12.—Lock tiers pronounced by Majority of International Board "the most dangerous feature proposed for any canal. Perilously near	

impracticability for the passage of battleships."

13.—Recorded by Minority itself: "If gates should be carried away results would be very serious indeed."

14.—Upper lake would empty into canal channel, and probably destroy everything to the sea, including tier and dam.

14.—Upper lake protected in addition to safety dam by five gates of divided lock. Amount that could escape before bear-trap dam was set would be caught in lower lake and be harmless to lower works at Mindi, where adequate sluices and another dam give further security.

X.—LOCK WALLS AT GATUN.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
DEFECTS—HEIGHT OF WALLS ABOVE ROCK.—LOCKS SHOULD BE SAFELY INCORPORATED IN HILL ITSELF WITHOUT EXCESSIVE BACKFILL NECESSARY TO LOCK FLIGHT.	
1.—Walls of upper lock in Secs. 2 and 3 extend above present hill, 85 ft.	1.—All walls imbedded in hill with minimum backfill.
2.—Walls of upper lock but 5 ft. above proposed lake.	
3.—Walls of middle lock in Sec. 6 rise 40 ft. above surface.	
4.—Walls of lower lock rise 28 ft. above swamp.	
5.—Walls of lower lock in Sec. 6½ drawn by Expert incorrectly setting them 61.67 ft. above datum instead of 33.33 ft.	

XI.—LOCK DIMENSIONS.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—First Experts' Lock designs incorrectly drawn as to lock lengths. Originally shown on drawings as 790, 790 and 820 ft. when safety gates are closed.	1.—Length 1,000 ft. with safety gates closed.
2.—Expert and Commission proposals abandoned, and locks now ordered 1,000 ft.—Good.	
3.—Width now but 100 ft.: (a) Newest express steamers show beam increasing relatively to length. (b) Battleships markedly greater in beam relatively to length.	2.—Width 115 ft.
4.—Very doubtful if lock will accommodate steamers longer than 900 ft.	
5.—Very doubtful if lock will pass 10 years hence our newest battleships.	
6.—Locks should be 115 ft. in width, not 100.	
7.—Forty ft. on lock sill in fresh water. Owing to difference in density, a vessel drawing 38 ft. at sea, may draw 39 ft. 4 in. in fresh water.	3.—Depth over all sills 40 ft. at mean low water; accommodate largest vessel at every stage of tide.
8.—Locks will pass ships whose	

loadline is 38 ft. at sea, with only 9-in. margin of water under keel.

9.—Locks at Sosa only 27½ ft. lift, hence will lock vessels of maximum draught but half the time. Depth over lower sill only 80 ft. at low tide. Range of tide overlooked and canal throttled.

XII.—PROVISIONS FOR SAFEGUARDING SHIPS.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—Prohibited from entering locks under steam. (Officially asserted and denied.)	1.—Vessels' power and shore winches.
2.—Means of locomotion provided: Commissioner—Pushing capstans! Expert—Tug pushing behind!	
3.—Double gates 80 ft. apart—insufficiency deduced: (a) Manchester accident—small steamer struck one; others gave way. (b) Welland accident—small steam barge went through 5 gates.	3.—Double end gates and one additional gate set midway of lock. Smaller vessels have 400 ft. of distance before striking second set. Large steamers have 150 ft. instead of 80.
4.—No such situation as at Gatun and Sosa flights ever before set; hence no appliances ever tried, let alone proved.	
5.—Experts gave provision up, while expressing belief something would be found. Allotted $2,000,000—a mere guess.	
6.—All leading types of dams examined. Bear-trap dam alone offers security. Not proposed by Experts or Commission. Requires bottom width and length on rock. Site offers no available foundation. Cannot be incorporated. All other types of safety dams applicable to low heads only.	6. 10.—Bear-trap dam well proved device incorporated, for which there is ample room. Device set well away from upper lock. Provides for all locks.
7.—Newest Commission proposals: Barrel, sectors and segments. Quite unavailing for tier conditions.	
8.—All safety appliances to be set within or immediately adjacent to upper locks.	
9.—Locks cannot be protected by such devices.	
10.—No safety dam for Sosa flight proposed by Experts.	

XIII.—LOCK FLIGHTS—SEPARATE LOCKS.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
NATURE OF DISASTER AT LAKES GATUN AND SOSA, FIRST AS TO LOCKS—SECOND AS TO GATUN DAM.	
1.—If ship overrides lower gate to upper lock, before upper gates are closed; five minutes are figured for setting safety devices; velocity attained by falling water would reach 30 miles an hour.	1.—Three-lake canal no flights.
2.—Weight of 500,000 tons, including ship, would be precipitated into middle lock. Cumulative volumes striking third set of gates	2.—All single, separate locks.

would release its waters with accelerated speed, would overwhelm last set in maelstrom rush, down the 85-ft. slope.

3.—SHIP. Ship and millions of pounds of steel gates, and millions of tons of water would tear everything to pieces, bury wreckage in fathomless gorge in marshes and plow a devastating way to sea.

4.—LOCKS. Locks must be eroded by lake torrent flowing through and around them.

5.—OTHER VESSELS. Every vessel in upper lake would be swept down or stranded. Every vessel in waiting basin and in channel hurled to annihilation.

6.—BUILDINGS, ETC. Everything in path of the flood would be carried to the far sea.

7.—REPAIRS. Would require years and vast cost. To fill lake alone would demand a year.

8.—"Locks in flight should be prohibited."

9.—The Gatun dam could scarcely escape destruction in case of accident.

3.—Minimum of peril.

4.—Bear-trap dam above single lock would hold back lake when set. Volume of five minutes' accumulation would spend itself in larger lower lake.

5.—Ship would be swept into lower lake with 28½-ft. fall. End gates would be torn out. Lock and ship would be the only damage.

7.—Volume of five minutes accumulation would spend itself in large lower lake.

8.—Gatun Lake would remain unemptied.

9.—Bear-trap dam and lower lake would save Gatun dam.

10.—At Mindi and Sosa locks similarly the safety dam and the sea would conserve the lakes.

XIV.—UNSAFE LOCK SITES—SAFE LOCK SITES.

85-Ft. Lock-Flight Project.

UNSAFE LOCK SITES.

1.—Lock flights have maximum of peril.

2.—Locks Nos. 1, 2 and 3 constitute Gatun flight:
Rock under only part of the flight.

3.—Rock at unknown depth north approach. Rock too deep at south approach.

4.—No rock available for proper safety dam at Gatun.

5.—No. 4 lock at Pedro Miguel site has been recently shifted in search of rock.

6.—Locks Nos. 5 and 6 constitute Sosa flight. Site too short for two locks and safety dam. Rock for safety dam and chamber extension very deep and great works must extend into 55 ft. lake. Yet to install one is imperative. Vast cost and very problematical. Divided lock system not applicable to lock flights.

62.5-Ft. Three-Lake Plan.

SAFE LOCK SITES.

1.—Single separate locks have maximum of safety.

2.—No. 1 lock Mindi:
Ample rock for one long lock.
Ample rock for concrete approaches.
Ample rock for bear-trap dam as safety device to

3.—No. 2 lock Gatun Hill:
Clay rock or tufa ample for one full-length lock.
Clay rock or tufa ample for masonry concrete approaches.
Clay rock or tufa ample for bear-trap dam safety device.

4.—No. 3 lock Pedro Miguel. Rock site ample and right for everything.

5.—No. 4 lock Sosa. Rock site ample and right for one lock, safety dam and approaches.

Incorporation of additional gate midway all locks gives small ships 400 ft. of distance instead of 80 before striking end gate.

CONCLUSION.

Locks in flight should be prohibited. They are on sites too small, and their debatable foundations and inherent peril and impracticability for merchant vessels and battleships make them a bane to the commerce of the world. Single separate locks should be incorporated instead.

XV.—THE LAKES.

85-FT. LOCK-FLIGHT PROJECT.

GATUN LAKE AT 85-FT. LEVEL.

1.—Offers sole provision for regulating Chagres floods.

2.—Compels high dam at Gatun over permeable gorges, whose strata are under great stress, and will become under greater stress from lake.

3.—Impels lock flights.

4.—Unprotected by suitable safety dam at Gatun and Pedro Miguel.

5.—Since it cannot be allowed to fill until Gatun dam is built, excavation in lake must be done in dry or must delay opening two or more years.

LAKE SOSA AT 55.

6.—Compels high Pacific dams.

7.—Compels lock flights.

8.—Work of excavation must be done in the dry, or delay canal.

9.—Dry excavation adds to estimates and was not figured.

62.5-FT. THREE-LAKE PLAN.

GATUN LAKE AT 62.5-FT. LEVEL.

1.—Provides for Chagres floods, but is supplemented by upper river regulation—normally empty basins.

2.—Admits of low Gatun dam with quarter volume.

3.—With Lake Chagres allows single separate locks.

4.—Protected by suitable safety dams at Gatun and Pedro Miguel.

5.—Satisfies navigation needs as fully. Owing to steepness of banks, is almost as large as 85-ft. lake.

6.—Gatun cut-off shortens route by 1 2-5 miles.

7.—Gatun cut-off reduces curvature between Bohio and Gatun.

LAKE PANAMA AT 26.5 FT. AND LAKE CHAGRES AT 33.5 FT.

9.—Economical hydraulic method available at dams.

10.—Does not interfere with railroad location, which requires but small work of raising.

11.—Low dams all on rock.

CONCLUSION.

To secure the supply of lockage water adequate to care for the commerce of the world, the summit level or lake must begin at Gatun or Mindi. A Gatun Lake at 62.5 ft. answers every necessary requirement and avoids the difficulties and risks inherent in a lake reached by the lock flight.

LAKE SOSA AT 55 FT.

1.—Summit lake above Pedro Miguel lock is inadequately safeguarded against accident to gates. No bear-trap dam installed.

2.—Overrunning these gates or breach of the Pedro Miguel dam would loose Gatun Lake, 171 square miles, into Lake Sosa, 8 square miles, and overtop dams. Breach of new Sosa-Corozal dam would wipe out the city of Panama unless the La Boca dam were dynamited or Sosa lock gates were opened. Latter sure to destroy lock-flight.

3.—Escape of Lake Gatun to Pacific sure to ruin channel through Culebra section in the greatest waterburst of time.

LAKE PANAMA AT 26.5 FT.

1.—Summit Lake—safeguarded by bear-trap dam and five gates at Pedro Miguel locks.

2.—No harm to City of Panama, as natural escape is at La Boca dyke, far to the westward, and Lake Panama at 26.5 ft. does not overtop city or hills or menace in any degree.

3.—Lake cannot escape on account of installation of proper safety dam.

CONCLUSION.

There should be no high lake overhanging the Pacific terminal city. Lake Sosa should be lowered to 26.5 ft., whereat it would be safe and equally serviceable for canal transit.

XVI.—DISTRIBUTION OF CULEBRA SPOILS.

85-FT. LOCK-FLIGHT PROJECT.

1.—Culebra precedence the system, and the steam shovel the adopted tool despite long French experience.

2.—Steam shovels through nine months so handicaped their output but fraction their capacity.

3.—At present scarcity of cars further limits output.

4.—Slides impeding as in French time. One extending back half a mile, slowly advancing like glacier.

5.—Material going to nearby dumps.

6.—Board called transportation and deposit of Culebra spoil greatest difficulty, yet left it unsolved.

7.—No spoil should be deposited where it can be washed back into channels. Should not go on watershed.

8.—Must go to watershed of San Juan Diaz, 20 miles from Obispo, to avoid canal watershed, or to the sea.

9.—Taking spoil to sea by barges is costly and wasteful.

10.—Present dumps too low and inconveniently arranged.

11.—Chairman reports Culebra lowered 65 ft. Two narrow septa for cross-over trains alone removed. Work confined to widening and removing slides.

62.5-FT. THREE-LAKE PLAN.

1.—Special rainproof land plant should supplant shovels where possible.

2.—Building terminal barrages would enable water plant to come to assistance of Culebra excavation in the dry.

3.—Dredging method cheapest, quickest, most sanitary; uses smallest labor force.

4.—Rain does not impede dredge excavation.

5.—No spoil deposited on watershed where liable to return to channel.

6.—Best disposition:

(a) In making breakwaters essential to right Panama harbor.

(b) In reclaiming an area continuous with the town site of Panama.

(c) Land would be valuable and sanitary.

(d) Park system and plaza along the front would add to attractiveness of terminal.

(e) Ample docks, etc., and naval stations could be arranged for.

CONCLUSION.

Many years of experience at the Culebra mass has proved the need of plant invincible to rain and of taking spoil to the Pacific, where there is the least annual rainfall. It should go to the water front and breakwaters to create a great south harbor for the Americas.

XVII.—PACIFIC TERMINAL LAKE AND DAMS.

85-FT. LOCK-FLIGHT PROJECT.

LAKE SOSA.

1.—Elevation of Lake Sosa set at 55 ft. above mean sea level is about 64.5 ft. above low tide. Lake Sosa must be reached by flight of two locks in Sosa Hill.

2.—There is not room at the site selected on west slope of hill for flight and proper lake approach and safety dam to safeguard lake level.

3.—Setting Lake Sosa at elevation 55 compelled Experts and Commission to plan three great dams and one small one:

62.5-FT. THREE-LAKE PLAN.

LAKE PANAMA.

1.—Elevation of Lake Panama set at 26.5 ft. above mean sea level, or 36 ft. above low tide.

Lake Panama reached by one separate lock in Sosa Hill—the Ancon-Sosa saddle.

2.—There is ample room either side of Sosa Hill for one pair of parallel locks and proper approaches.

3.—For lake at 26.5 ft. only a small dam and sluice-barrage (adjacent to lock) are required.

Dams.	Length Ft.	Vol. Cu. Yds.
1.—La Boca.....	4,800	6,800,000
2.—Sosa-Ancon ..	1,750 }	5,098,000
3.—Ancon-Corozal.	5,600 }	5,980,000
4.—San Juan.....	*500	80,000
Total	12,650	12,360,000

*Estimated.

NOTE.—In place of dams 2 and 3 the retiring Chief Engineer and Commission have substituted one from Sosa to Corozal, September 6, 1906, without a boring. The boring party in the first hole 500 ft. from Sosa Hill had not found rock at 70 ft. below sea level early in February.

The tally with this change runs:

Dams.	Length Ft.	Vol. Cu. Yds.
1.—La Boca.....	4,800	6,800,000
2.—Sosa-Corozal...	6,600	5,897,000
3.—San Juan.....	*500	80,000
Total	11,900	11,777,000

*Estimated.

Dams.	Length Ft.	Vol. Cu. Yds.
La Boca.....	4,200	1,300,000
Sosa-Ancon	1,000	Concrete
Total	5,200	1,400,000

For the low level Lake Panama the dams are but 44 per cent. of the length and 13 per cent of the volume of those required to impound Lake Sosa.

4.—Great dams—great cost, great hazards to canal, commerce and city.

5.—Long period of construction because car fill method is required. Height beyond mechanical limit of pumping dredges; hence, very long before swamps are covered by lake. On square mile is left a morass right below Ancon Hospital and adjacent to Panama.

6.—Floating plant precluded for many years, until great dams completed.

7.—Excavation saved by Lake Sosa does not compensate for extra lock and tremendous dams and allied works and risks.

8.—Lake overtops San Juan Hill rim.

9.—High lake forces rebuilding of Panama Railway at unneeded expense.

10.—High dams in event of disaster very difficult to repair and demand a long time.

11.—Lake navigation little over 5 miles. No advantage to canal transit in high lake.

4.—Low dams—low cost, no hazards to city and minimum to canal or commerce.

5.—Very short time needed to build La Boca dyke. All within pumping limit of dredges in excavating to firm foundation and in placing earth portion of dam. Hence all unsanitary swamps of Rio Grande quickly submerged.

6.—Floating plant can, in one year, reach south side of central mass to assist excavation and distribution and can readily dig channel in lake and naval basin below Ancon.

7.—Excavation in lake mostly favorable and all dredgable in connection with suitable rock-breaking plant.

8.—Low lake comes safely below ridge west of San Juan Hill—west of La Boca.

9.—No change in alignment of railway necessary—simply grade-raising.

10.—Low dams quickly restored.

11.—Navigation in lower as long as in higher lake.

CONCLUSION.

Lake Panama at 26.5 ft. should be restored, the high dams eliminated with their problems of construction and hazard. Low dams should be substituted, the lock-flight at Sosa done away with, and a single separate lock installed. This change will save in the Pacific section over $6.000.000.

XVIII.—PACIFIC TERMINAL.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
Expert and Commission's recommendation:	
1.—Pacific channel shallower than Atlantic by a fathom.	1.—Approach away from reef.
2.—Old approach the worst of all.	2.—Approach full depth at mean low tide.
3.—Sailing line prolonged passed directly over San Juan reef.	3.—Central trough is approach line direct to Sosa lock.
4.—Axial line wrong for ship.	4.—Breakwater arms inclose large harbor area.
5.—Channel so shallow that 330 days in the year had less than 37 ft.	5.—Breakwater arms inclose large spoil area.
6.—Remaining Commission Engineers discard Expert and Commission approach: (a) Abandon breakwaters. (b) Relocate line taking West Trough—second best approach.	6.—Hold currents parallel to ship's course entering and leaving.
7.—Channel undefended by breakwaters must constantly shoal from shore currents.	7.—Waves entering harbor would be absorbed.
8.—Ebb and flood tide currents become at right angle to ship's course.	8.—Surges strike ship directly before or behind.
9.—Swells entering harbor would strike ships on the quarter.	9.—Entrance straight and one of the easiest in the world to negotiate.
10.—New alignment planned to deepen channel 5 ft. Hence Atlantic channel still shallower than Pacific at mean low water.	10.—Large harbor basin at foot of Ancon-Sosa lock.
11.—The governing plane of navigation the world over is mean low tide, not mean sea level, as Commission erroneously employ.	11.—Depth of 44 ft. in harbor measured from low tide.
12.—Channel width 500 ft.	12.—Channel width 600 to 1,000 ft.
13.—Difficult to defend.	13.—Easy naval defense.

Conclusion.

Breakwaters are indispensable at Panama for the safety and convenience of navigation, to neutralize and prevent currents on beam entering and leaving; to create the nearest spoil area for Culebra; to prevent resilting of approach and endless dredging and to afford best military protection.

XIX.—ALIGNMENT AND TRANSIT TIMES.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—Curvature affecting navigation, 140° 55′.	1.—Curvature affecting navigation, 139° 40′.
2.—Total curvature, 595° 40′.	2.—Total curvature, 530°.
3.—Length from deep water contours, 50.12 miles.	3.—Length from deep water contour, 48¼ miles. Has advantage of Gatun cut-off.
4.—Time of transit, 12.982 hours.	4.—Two lock 10.586 hours. Transit time.
5.—Longest, most hazardous to traverse.	5.—Four lock, 11.027 hours.
	6.—Lake canal terminal locks are passed during necessary stay at terminals. No other canal admits of this time economy.
	7.—Shortest and most safe for ships.

XX.—PANAMA RAILWAY.

85-Ft. Lock-Flight Project.	62.5-Ft. Three-Lake Plan.
1.—Entire line to be relocated.	1.—Relocated only between Obispo and Pedro Miguel.
2.—Mount Hope to Gatun, length increased and line around Mindi Hills to gain Gatun summit, to be newly built.	2.—No change—grade raised.
3.—Gatun to Obispo all to be newly built, with greater embankments across arms of Lake Gatun, deep cuts, tunnels, bridges and viaducts—an omnious profile meaning many millions for a useless line.	3.—Substitutes fast steamer or car ferry from Gatun to Obispo, saving many millions.
4.—When canal is built from Obispo to Pedro Miguel a new line must be built on Culebra terrace, east side of canal.	4.—Obispo to Pedro Miguel, new line on terrace of Culebra section.
5.—Line from Pedro Miguel to Panama and La Boca all to be newly built.	5.—No change of line except grade raising.
	6.—Electric passenger line from Colon to Mindi and Gatun, steamer to Obispo, and electric car line from Obispo to Panama proposed. No need for carrying freight in cars when canal is finished.
7.—Cost probably $10,000,000.	7.—Cost not over one-twentieth, or $500,000.

THE RAILROAD.

Almost since its construction it has been at the mercy of the transcontinental roads, and steamship companies bound up in contracts in restrain of trade. Coming into government possession its shackles should have been broken.

It holds the key to transcontinental rates and could free Pacific commerce.

The un-American policy of the Secretary of War and the management keeps the anomaly of a Government-owned corporation fettering American navigation.

Utilized for covering purchases and business transactions pertaining to canal proper.

Road virtually superseded by canal when constructed.

Conclusion.

To expend any more money than is absolutely indispensable upon this road would be unwise. The Three-Lake Plan preserves the present alignment and calls for but some grade raising. The road might advisedly afford free transport to goods carried in American ships, thus upbuilding our needy merchant marine.

XXI.—PERSONNEL RESPONSIBLE FOR 85-FOOT PROJECT.

I.—COMMISSONERS.

First. Advised sea level.

Second and Third. Bohio Advisers; dams located upon defective data; scheme collapsed. Condemned dams at Isthmus not founded on rock, now support huge Gatun dam on alluvium. Located Gatun dam with three borings under crest 8,640 ft.

Fourth and Fifth. Not engineers at all. One a successful Governor; one a railroad reorganizer.

Sixth. Moved adoption of sea level in Walker Commission.

II.—EXPERTS.

First. Designer of Lock Flight.—Condoned Bohio dam adviser. Located lock flight on four or rather three bores for data. "Did not know length of Gatun Hill." Locks announced as 900 ft. long measured in drawings 790, 790 and 820 feet.

Second. Lock Expert. Supported flight on four borings. Sent to Senate latest lock design with middle wall 28½ ft. too high. Neglected range of tide on Pacific in designs. Owing to 27½-ft. lift at Sosa lock, canal can be used by large ships but half the time!

Third. Dam Expert. Located Gatun dam with three borings under its entire crest. Sent profile to Senate suppressing artesian revelations of gorge bores. Advised dam with proviso of cutting off all subterranean flow. Cutting off flow proving impossible, advised dam next without cutting off flow.

Fourth. Had within three months written a book emphasizing special dangers of 85-ft. project and supporting canal at 61.5.

Fifth. Advised in 1902 Darien-Madingo, tunneled lockless, as trans-isthmian solution.

Engineers going with Secretary of War, March 20th, to advise or make final decisions regarding plan of canal.

They are—

No. 1.—Who designed the lock flights—Bohio Engineer.

Whose lower Gatun lock walls were 28 1-3 ft. too high.

Whose Sosa lock's 27½ ft. lift, neglected tide range and made canal inaccessible for largest craft half the time the year round.

No. 2.—Dam expert who provided for cutting off underground flow through geologic gorges at Gatun, which is impossible.

They made the most deplorable guesses under grave responsibilities in all the annals of engineering. The prototype of their Panama dams, the Wachusett, failed in crucial mass, April, 1906.

III.—SECRETARY OF WAR.

Conclusion of Personnel.

If the canal design is to be made right it must be studied and settled by men unhostaged to the past, who will weigh plans by their innate fitness alone.

XXII.—CANAL PLANS.

High level and sea level evolution since 1879. Struggle continuous for supremacy. Both at each step incorporated all features sponsors knew and deemed good for types.

ABANDONED— MAJORITY OF BOARD.	APPROPRIATED FROM THREE-LAKE PLAN—UNCREDITED. MAJORITY OF BOARD.
1.—Tunnel 3½ miles long, $5,000,000. Diversions 60 miles long, paralleling canal overhanging it in menace.	1.—Divided Chagres. Use of canal bed for discharge.
2.—Earth dam at Gamboa for upper Chagres regulation.	2.—Masonry dam at Gamboa.
3.—Solid dam at Gamboa.	3.—Sluice dam at Gamboa.
4.—Upper reservoir unlowerable below still of dam.	4.—Reservoir to be lowered, hence —empty basin principle.
5.—Discharge of floods borne to Atlantic alone.	5.—Discharge to both oceans in controllable volumes.
6.—Terminal lock site Miraflores.	6.—Terminal lock site Ancon-Sosa.
7.—Width 150 ft.	7.—Width 200 ft.
8.—Depth 35 ft.	8.—Depth 40 ft.
	9.—Barrages at La Boca and Sosa. Terminal lakes for lock canal.
MINORITY.	MINORITY.
10.—Terminal lock Miraflores.	10.—Ancon-Sosa lock-site.
11.—Terminal lake (assigned to M. Kleitz).	11.—Terminal lake.
12.—Width 150 ft.	12.—Width.
13.—Depth 35 ft.	13.—Depth.
14.—Experts approach via east trough.	14.—Second choice of approach via west trough.

Entire three-lake four-lock canal set forth by Majority as best lock canal for Panama. Its second choices of lock-sites presented. Mindi not examined.

Minority conceeds superiority in the following:

1.—Its smaller head of water on dams.

2.—Smaller height of embankments.

3.—Reduction of locks from 6 to 4.

4.—Basin above Gamboa dam affords control of floods with least fluctuations of water in canal.

CONCLUSION.

The Three-Lake plan has in every principle received indorsement of both contending parties. It is the only safe, sufficient and right design for Panama.

XXIII.—SANITATION.

1.—Isthmian Repute of 400 years unsanitary.

2.—Eighty-five-ft. design preserves all swamps during construction. The Mindi-Gatun swamps permanently.

3.—Isthmus announced as sanitized throughout.

4.—French unsanitary conditions reported changed. Yellow fever not an abiding presence:

(a) 1890, no yellow fever. (b) 1891, but 17 cases. (c) 1891 to 1896, but 2 cases. (d) Three intervals of French construction occupancy with not a case. (e) Three consecutive years without a case. (f) Four other years with but a few sporadic cases. (g) Two of these last showed but one a year.

5.—Permanent disease is Chagres or malarial fever.

6.—No radical engineering programme to eliminate foci of disease.

7.—Disease of French times laid by Commission to conditions since removed:

(a) "Times of orgy." (b) "For eight years, money, absinthe, champagne, rum, ran like water." (c) "Carnival of dissipation, disorder and crime." (d) "Mortality was great because of sanitary and social conditions."

Deceiving Announcements.—Isthmus announced as now sanitized by—Report supplied to Executive by sanitary officer, chairman in recent Kansas City and Chicago speeches, and by Commission reports.

Real Sanitary Facts.—Mortality rate and hospital record markedly lower under French than under Americans. Chief sanitary official uses as basis divisor total force. French used effectives only.

Using similar basis for both gives: French annual death rate 6.32 per hundred. American 6.62, or 50 per cent. more than certified, which is 4.403. American record worse than French average over all their yellow fever years.

The 85-ft. scheme is inherently one of the least sanitary and most difficult to sanitize.

Official sanitary statistics are not true. Sudden gain of population in May, 1906, of 6,339, when excess arrivals over departures were but 3,715. Sudden gain in July, 1906, 14,318, when net arrivals were 1,479.

Low mortality and sick rate figured upon erroneous population statistics. Americans use as divisor full roll. French used mean effectives. Taking similar basis Americans lose 6.65, French 6.32 per hundred annually.

If population be taken from Quarantine and other records: American ratio is again 6.58. During ten months of 1906, 89 employes a day entered the hospital; 120 per cent per annum. During past ten months of 1906, including railroad employes, 150 per cent per annum.

Besides this hospital record a high percentage are treated by visits in quarters, and in addition the dispensary rate for treatment of malarial cases has been several times the hospital rate. (Vides Monthly Sanitary Records.)

Relative Expenditures for Quarters.—White (5,101) for quarters, hospitals, repairs, $1,537,626. Administration buildings, etc., double the investment. Negroes (22,108), $254,865. When conditions of labor are reckoned fifty times as much as has been done to safeguard the white as the colored employe, which in part accounts for the abnormally high hospital and death rate of the Zone. The mortality rate in the Zone is closely 90 per thousand, over 4½ times the normal.

Collateral Evidences.—Steamer Whitehall, from Colon, reaching New Orleans with but 2 of crew immune. Of 21 men, three died, and 16 were in hospital. U. S. S. Columbia, from Colon, of 298 officers and men, 215 had acute malarial paroxysms. Sanitizing cost, $6,500,000 to January 1st, 1907.

Three-Lake canal would first reduce land width to 8 miles, eliminating the other 30 miles from all need of sanitizing. The centers of disease breeding would be drowned. The lake breezes would refresh and stimulate and perfect sewage would be secured. There would still be enough work left to make Mindi, Gatun, Culebra and Panama health resorts by the best that land skill can compass.

The Lake canal is the sanitary design which will save valuable lives and millions of money.

CONCLUSION.

Radical sanitary engineering by canal design is essential at Panama. By cutting the land width in the Isthmus to 8 miles, the right alliance is given the sanitary corps and the best safety to life and health secured.

XXIV.—LABOR.

Policy—bringing large forces prematurely. Plan of canal knocked out by Bohio dam fiasco. Present 85-ft. plan demands a profligacy of labor. Construction was to be preceded by sanitation. Construction was to be preceded by providing plant.

But large forces were sought and brought and came nevertheless from Jamaica, Barbados, Martinique, smaller islands, neighboring coasts. These forces set at: sanitizing, building, fighting vegetation (nearly 5,000); distributing riot of supplies, 6 to 16 per cent of force. Incidentally a little canal excavation "to determine unit costs" and supplementary railroad work.

In 1908 paying through passengers numbered 2,300. October 1, 1904, to September 30, 1906, arrivals and departures totaled 159,320. Movement of 150,000 due to labor propaganda. Immigrants there died, 1904 to 1906—From 5,500 to 6,100!

In Commission service (1906) Whites: Employed, 4,316; departed, 2,525; remained, 1,791; 41½ per cent. Engaged, 4,869; accepted, 3,962; reported for work, 3,243. 25 per cent failed to go to work. 60 per cent left. Islands one by one ceasing to supply labor.

Contract for Coolies.—If force of 15,000 are to be kept at the Isthmus, at least 95,000 must be brought; at least 9,500 will die; at least 10,500 will be invalided home; at least 62,500 will enter hospitals; at least 190,000 fares across the Pacific. Coolies stampede from fumigation and disease. 10 per cent is the death rate given in early statistics at Panama. Suicide under indenture conditions.

Seeking Spaniards and Italians. 31,000 additional men imperative at high French efficiency to finish 85-ft. canal in 8 years. Vast forces compelled by 85-ft. design: Gatun dam, 21,000,000 cu. yds. Pacific dams, 12,000,000 cu. yds. Lock flights. Eliminating all but 8 miles of land, leaves small forces at Mindi, Gatun dams, Sosa and reasonable force in Culebra. No need for Chinese labor in executing the Lake plan.

CONCLUSION.

The way to solve the labor problem is to adopt the most sanitary project, the one employing the most water-borne plant, and to install mechanisms invincible to rain. Then skilled white labor and machines will largely supplant colored labor and health consuming methods. The design which calls for the smallest labor forces is the wisest. The simplest canal in construction is the one which eliminates huge dams, and brings water-borne plant to replace labor and economize cost.

XXV.—FINANCIAL.

JANUARY 1, 1907.

1.—Appropriation, $145,000,000.

2.—85-ft. estimate, $139,750,000.

3.—Called to June 30, 1908, $87,600,000. June 30, 1909, $120,000,000.

4.—Remaining June 30, 1909, $25,000,000 to complete canal!

5.—If 1906 rate of call continues for eight years deficits will be $100,000,000.

6.—If past rate increases, deficits increase. Additions to $100,000,000 will accrue through:

(a) WAGE—25,000 additional men announced in Message, 25,000 men, including railroad force engaged on collateral work, gives $92,000,000 more than past rates in wage.

(b) PLANT—Utter unpreparedness shown at every point and vast plant imperative before large execution possible.

(c) 1, to excavate Atlantic approach; 2, dig Mindi clay rock; 3, excavate and transport spoil to Gatun; 4, construct lock flight; 5, spillways, excavate in lakes; 7, build Pacific dams; 8, construct Sosa flight; 9, excavate Pacific approach.

7.—MATERIALS AND SUPPLIES (including plant)—French rate yearly on small canal around $4,000,000. Saturnalia of orders. Suppression of unvouchered accounts for $7,750,000, as of January 1, 1907, in official announcements and speeches of Secretary of War and Chairman of Commission. American rate nearly $14,400,000 under last Commission. At past ratio $115,200,000 more will be required.

8.—EXCESS COST OF DELAY.—(a) One-sixth in earth turn over have been achieved in four years, all in soft upper deposits. Harder and more difficult materials untouched. (b) Concrete construction untouched. (c) French, with highest rate of canal building yet reached, finished but two-fifths of their small canal in ten years. (d) Unpreparedness precludes extensive advance of pace for at least one year. (e) Delay unquestionable. Excess cost incidental to delay.

9.—UNCOUNTED ITEMS—(a) Additions from digging clay rock Mindi-Gatun section. (b) Building Gatun dam and Pacific dams largely by dry method. (c) Lengthening locks to 1,000 ft. and widening. (d) Equipping harbors and canal, making reception basins. And many other items.

10.—INTEREST—(a) Two per cent 30-year bonds means of payment. (b) Interest on extra $100,000,000 is $60,000,000. (c) Excess cost and interest bring expenditure of 85-ft. lock-flight project to at least $300,000,000, and probably far more.

11.—INVESTMENT WARRANTED—Congress authorized $145,000,000. If appropriation not exceeded canal can be self-sustaining in 5½ years.

12.—WASTE OF FUNDS AND REMEDY—Of the millions already expended at least $30,000,000 from the standpoint of a correct design and programme of execution has been wasted. The only way to avoid or diminish further tremendous losses and vast deficits is to abandon the lock-flights and high dams and the programme which they entail and adopt the three-lake four-lock (or two-lock project) and execute it under a rational contract system.

FINIS.

Since to secure sufficient lockage capacity for all time the summit level must begin at Mindi or Gatun and the only lock sites then possible are at Mindi, Gatun, Pedro Miguel and Sosa-Ancon the simple formula to compel the adoption of a sensible and safe plan of canal is the injunction.

"LOCKS IN FLIGHT MUST BE PROHIBITED."

When lock flights are prohibited everything else must follow, low safe dams, separated locks, and low head lakes.

In this single proviso is inherent the dispositions of the right canal—its supreme advantages to navigation and commerce, to construction, sanitation and labor; its solution of all the momentous problems, financial, technical and executive, which are involved in the nation's work of opening to the world a waterway across the American Isthmus. The Panama Canal right, but right or wrong, the Panama Canal!

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